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# *The Research Quarterly*

of the American Association for Health, Physical Education, and Recreation

Volume 21 OCTOBER, 1950 Number 3

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# Further Studies on Some Effects of Physical Fatigue on the Peripheral Circulation of Athletes

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IN A PREVIOUS study of the malarial incidence in the student population of Southern Illinois University (1), many cases of recurrent malaria were found, which were without a known history of reinfection, and in most instances, without a remote possibility of reinfection. Such recurrences could usually be ascribed to the presence of bodily conditions such as long-continued periods of physical exhaustion due to extremes of fatigue or other causes, or in some cases to episodes of debilitating bodily conditions following an infection or protracted malnutrition.

The suggestion arose that in those cases which followed fatigue, a possible explanation might be found in the peripheral circulation, more specifically in the blood cells themselves. Accordingly, experiments were devised to test the effect of prolonged vigorous fatiguing exercise upon the blood picture. It had been shown in an earlier preliminary study on forty athletes (2) that there was a significant early lymphocytosis following indulgence in exercise to the point of fatigue. The present report involves an extension of this study and includes data collected on eighty-seven more athletes as follows: complete studies on seventy-seven of these students, and supplementary studies on the other ten. Volunteer students in physical education classes and participants in several sports were asked to cooperate in submitting to the following tests; blood smears were made in the usual manner *immediately before*, and again *immediately after* fatiguing exercise and in some experiments, at several succeeding intervals throughout the recovery period following fatiguing exercise. Slides were stained with Wright's stain and buffered. The following microscopic observations and measurements were made on control and experimental slides; differential white cell count, the number of divisions of the nuclei of polymorphs, the appearance of red blood cells, and the measurement of their diameters. The physical condition of each participant was checked including examination for organic or infectious disease. The average health score for women was 81 per cent, and for men, 90 per cent. All sports except basketball and physical education classes took place out of doors. In those cases where repeated readings were

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made at intervals, the student was asked to give a complete report of his activities for the time covered by the duration of the experiment.

**Data**

The summarized results of the microscopic examinations of control and experimental slides are presented in the following tables. Significant changes were noted in the relative numbers and per cent of both polymorphs and total lymphocytes (see Tables 1 and 2) and in the number of nuclear lobes of the polymorphs (Tables 3 and 4). The diameters of red blood cells were measured but no significant change in size or outline of these cells was noted in these experiments.

Values for the diameters of red blood cells are necessarily not as dependable when measured in dry, stained films as they would have been had living cells been measured. However, since the results are fairly consistent and large numbers were used, it may be of interest to point out the results. The average diameters measured with an ocular micrometer ranged from 7.80 $\mu$ to 8.07 $\mu$ before exercise, and from 7.58 $\mu$ to 7.98 $\mu$ after exercise. These figures are based on the values obtained by averaging 77 x 50 cells *apiece* for control and experimental values, respectively.

It soon became evident, however, that the immediate effect of fatiguing exercise was most marked, and most reliable, when the results of fatiguing exercise were studied in their effect on the white blood cells.

In Table 1 are recorded the results of fatiguing exercise upon the relative number and per cent of polymorphs and of lymphocytes before and after exercise.

In Section I, Table 1, Column I indicates the type of activity, Column II, the number of participants in each activity, Columns III and IV, the average relative numbers of polymorphonuclear leucocytes per hundred white blood cells counted on each slide before and after exercise respectively. (Values are given in nearest whole numbers.) These averages were obtained by adding values for individual students and dividing by the number of participants—thus the number 66 (or more accurately 65.7) in Column III is 1/37th of the total number of polymorphs (2432) found in a count of 3700 white cells. Of the same 3700 white cells, 1177 were lymphocytes, large and small and the value 32 (31.9), Column VI, represents the average value of 1/37th thereof. The remaining 91 cells of the total 3700, or an average of 2.46 cells per participant, includes the types of other white cells which normally occur in normal blood smears in low percentages and in these experiments showed no change in relative frequency following exercise. Columns V and VIII show respectively the relative percentages of decrease in number of polymorphs and increase in number of lymphocytes (large and small) following each activity, while Columns VI and VII show the average relative numbers of lymphocytes per hundred white cells counted on each slide.

In Section II of Table 1 are recorded averages calculated for all controls

and all participants (87 in each case). There is a greater spread in range of values after exercise than in the controls, before exercise. This is true for both polymorphs and lymphocytes, and results are recorded in Section III of Table 1. The values for total participants in all sports show the same general trend as for individual sports.

A study of Table 1 reveals that there is a relative percentage decrease in polymorphonuclear leucocytes (Col. V) and a relative percentage increase in lymphocytes (Col. VIII) following participation in each of the various

TABLE 1

*The effect of fatiguing exercise on the differential white cell count*

| SECTION I | | POLYMORPHONUCLEAR LEUCOCYTES | | | TOTAL LYMPHOCYTES | | |
|---|---|---|---|---|---|---|---|
| Column I | Column II | Column III | Column IV | Column V | Column VI | Column VII | Column VIII |
| Type of activity | Number of students | Before exercise | After exercise | Per cent decrease (Col. III–IV) | Before exercise | After exercise | Per cent increase (Col. VI)–VII) |
| | | Aver. No. Per 100 Cells | Aver. No. Per 100 Cells | | Aver. No. Per 100 Cells | Aver. No. Per 100 Cells | |
| *Women's P.E.* Running Games | 37 | 66 | 59 | —10.80 | 32 | 38 | +17.00 |
| *Men's Activities* | | | | | | | |
| Baseball | 7 | 60 | 56 | —6.67 | 36 | 41 | +13.89 |
| Football | 19 | 69 | 57 | —17.40 | 25 | 37 | +48.00 |
| Track | 13 | 56 | 55 | —1.78 | 41.9 | 42.2 | +0.71 |
| Basketball | 11 | 66 | 52 | —21.21 | 28 | 44 | +57.14 |
| SECTION II | | Aver. of all controls | Aver. of all expts. | | Aver. of all controls | Aver. of all expts. | |
| Total for all activities | 87 | 64.6 | 56.8 | —12.07 | 31.7 | 39.5 | +24.6 |
| SECTION III | | Range of individual values for 87 participants | | | | | |
| | | Before exercise | After exercise | | Before exercise | After exercise | |
| All activities | 87 | 32–80 | 31–89 | | 14–56 | 11–67 | |

sports listed. The effect is greatest in the sports requiring long-sustained effort and continuous competitive individual performance, e.g., football and basketball. As individual competition becomes lessened and the period of individual activity shortened, the effect on the blood picture becomes less marked, as in baseball, running games, and track.

Table 2 records the individual percentage increase or decrease in values of polymorphs and lymphocytes following exercise of participants.

In Table 2, Section A, Column I lists the type of activity; Column II, the number of participants in each activity; Columns III to VII, the num-

ber of participants in each activity showing varied percentages of decrease in relative number of polymorphs after exercise. Column VIII records the number which showed neither a decrease nor an increase in relative number of polymorphs after exercise. Columns IX to XIII record the number of participants in each activity showing varied percentages of increase in relative numbers of polymorphs after exercise. Section B of Table 2 shows

TABLE 2

*Range of individual values of polymorphs and lymphocytes following exercise*

| | | PERCENTAGE DECREASE | | | | | | PERCENTAGE INCREASE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column I | Col. II | Col. III | Col. IV | Col. V | Col. VI | Col. VII | Col. VIII | Col. IX | Col. X | Col. XI | Col. XII | Col. XIII |
| Activity | No. of part. | Over 30% | 20–29% | 10–19% | 5–9% | Less than 5% | 0 | Less than 5% | 5–9% | 10–19% | 20–29% | Over 30% |
| **Section A—Polymorphs** | | | | | | | | | | | | |
| Women's P.E. | 37 | 0 | 7 | 10 | 9 | 3 | 2 | 4 | 1 | 1 | 0 | 0 |
| Baseball | 7 | 0 | 0 | 2 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| Football | 19 | 3 | 5 | 6 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 |
| Track | 13 | 2 | 1 | 2 | 0 | 1 | 0 | 2 | 1 | 1 | 2 | 1 |
| Basketball | 11 | 3 | 3 | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Totals | 87 | 8 | 16 | 23 | 11 | 7 | 6 | 9 | 2 | 2 | 2 | 1 |
| | | 58 | | | | 22 | | 7 | | | | |
| Per cent | 100% | 67% | | | | 25% | | 8% | | | | |
| **Section B—Lymphocytes** | | | | | | | | | | | | |
| Women's P.E. | 37 | 1 | 0 | 1 | 2 | 2– | 2 | 2 | 2 | 7 | 5 | 13 |
| Baseball | 7 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 2 |
| Football | 19 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 3 | 1 | 12 |
| Track | 13 | 1 | 1 | 3 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 4 |
| Basketball | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 7 |
| Totals | 87 | 2 | 2 | 5 | 5 | 4– | 3 | 5 | 3 | 13 | 7 | 38 |
| | | 14 | | | | 12– | | 61 | | | | |
| Per cent | 100% | 16% | | | | 14% | | 70% | | | | |

a tabulation of numbers of participants in each activity similarly grouped as in Section A but with reference to the values of the per cent decrease or increase of the relative number of lymphocytes following exercise.

From an examination of Table 2, it becomes evident that a total of 58, or 67 per cent, of the total number of participants showed a *significant decrease in the relative percentage of polymorphonuclear leucocytes*, and a total of 61, or 70 per cent, of the total number of participants showed a *significant increase in the relative percentage of lymphocytes.*

In Table 3 are recorded averages of nuclear divisions in polymorphs before and after exercise, and the percentage increase or decrease thereof following exercise.

In Table 3, Column I lists the type of activity, Column II, the number of participants, Columns III and IV, the average number of nuclear

TABLE 3

*Average number of nuclear divisions of polymorphonuclear leucocytes*

| COLUMN I | COLUMN II | COLUMN III | COLUMN IV | COLUMN V |
|---|---|---|---|---|
| Activity | Number of participants | Average number of nuclear divisions | | Per cent increase or decrease |
| | | Before exer. | After exer. | |
| Women's P.E. | 36 | 4.31 | 4.51 | +4.87 |
| Baseball | 7 | 4.13 | 4.27 | +3.39 |
| Football | 15 | 4.14 | 4.24 | +2.40 |
| Basketball | 11 | 4.21 | 4.18 | −0.007 |
| Track | 8 | 4.02 | 4.16 | +3.48 |
| Total | *77 | | | |

* Complete studies on only 77 slides.

TABLE 4

*Range of individual values of percentage increase or decrease in the number of nuclear segments of polymorphonuclear leucocytes following exercise*

| ACTIVITY | NUMBER OF PARTICIPANTS | PERCENTAGE DECREASE | | | | | PERCENTAGE INCREASE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Col. III | Col. IV | Col. V | Col. VI | Col. VII | Col. VIII | Col. IX | Col. X | Col. XI |
| Column I | Column II | 20% | 15% | 10% | 5% | 0 | 5% | 10% | 15% | 20% or more |
| Women's P.E. | 36 | 0 | 0 | 3 | 4 | 0 | 12 | 11 | 2 | 4 |
| Baseball | 7 | 0 | 1 | 0 | 0 | 0 | 3 | 3 | 0 | 0 |
| Football | 15 | 0 | 2 | 4 | 1 | 0 | 0 | 3 | 4 | 1 |
| Basketball | 11 | 0 | 1 | 4 | 0 | 1 | 1 | 4 | 0 | 0 |
| Track | 8 | 0 | 0 | 1 | 2 | 0 | 1 | 3 | 0 | 1 |
| Totals | *77 | 0 | 4 | 12 | 7 | 1 | 17 | 24 | 6 | 6 |
| | | 16 | | | 25 | | 36 | | | |
| Per cent | 100% | 21% | | | 32% | | 47% | | | |

* Complete studies on only 77 slides.

divisions before and after exercise, respectively. Column V records the percentage decrease or increase of nuclear divisions of polymorphs following exercise of participants. In each of the sports, except basketball, there was a noticeable percentage increase in nuclear lobulation of polymorphs found in the peripheral circulation following exercise.

Since the normal number of nuclear lobes is necessarily small, the occurrence of a large percentage increase or decrease after exercise is obviously impossible. Again, the range of values was greater after exercise.

Table 4 records the grouping of results according to amounts of percentage decrease or increase in number of nuclear divisions of polymorphs following exercise of participants. This Table is comparable to Table 2 in which the data for numbers and percentages of polymorphs and lymphocytes are similarly treated.

Column I of Table 4 indicates the type of activity, and Column II, the number of participants in each activity. Columns III to XI record the number of participants in each group showing varied values of percentage decrease or increase in nuclear lobulations of polymorphs. A total of 36 (Columns IX to XI) or 47 per cent of all cases showed an increase of 10 per cent or more, while 25 (Columns VI to VIII), or 32 per cent, of all cases showed either an increase or decrease of 5 per cent (or less), in the number of nuclear lobulations of polymorphs, while only a total of 16, or 21 per cent, showed a significant percentage decrease.

## DISCUSSION OF DATA

These experiments have brought out further evidence that fatiguing exercise produces a noticeable effect on the peripheral circulation. The most significant change is in the relative proportions of the white cells. The effect is constant, marked, but relatively transitory. The polymorphs become relatively fewer, while there is a relative increase in the number of lymphocytes, with the effect most marked among the large lymphocytes. The effect is distinguishable shortly after fatiguing exercise, and persists for a considerable period of time, usually diminishing gradually until the normal blood picture again appears, approximately within two or three hours after exercise. There appeared to be the same trend of effect following the various types of exercise. Such an effect is comparable to that accompanying or following certain types of infection, and is sometimes referred to as an "irritation phenomenon." It represents a typical physiological lymphocytosis.

While the increase in the number of nuclear divisions of the polymorphs is not nearly as constant nor the percentage increase very large, there is a noticeable trend toward the more complete lobulation of nuclei following exercise. This suggests that since relatively fewer polymorphs are found in the peripheral blood stream following fatigue, and the nuclei of these have more divisions, younger polymorphs are not entering the peripheral circulation as fast as the old ones disappear.

The obvious effect on the red blood cells is less marked. There was no noticeable difference in either the depth of color or the uniformity of shape, and only very little effect on the size of the red blood cells. Any change in diameter of these cells could have been due to such factors as changes in the permeability of the cell wall, and are probably associated with changes in the chemistry of the plasma following fatiguing exercise.

It would have been highly desirable to include other experiments on red and white blood cells in the living state for the direct measurement of diameters, and for permeability and fragility tests, sedimentation rate studies, changes in electrical surface charges of the cells, etc., but unfortunately the experimental set-up at the time of the experiments did not permit such an extensive study.

## CONCLUSIONS

1. Further evidence is presented that physical exercise to the point of fatigue produces a significant effect on peripheral circulation. This effect, though transitory, is relatively immediate.
2. The polymorphonuclear leucocytes seem to appear in relatively fewer numbers, immediately after fatiguing exercise.
3. There is a slightly greater degree of nuclear lobulation of polymorphs following fatiguing exercise.
4. There is a marked early lymphocytosis following fatiguing exercise.
5. The lymphocytosis is most marked in the sports characterized by long-sustained activity and continued competitive individual physical and mental performance, as in basketball and football.

## SUMMARY

Results of studies such as the above point to the close tieup of fatigue and its effect upon the peripheral circulation. The frequency with which physical fatigue is associated with increased susceptibility to certain diseases may have a partial basis in such circulatory effects.

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# Time Patterns in Motor Learning

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THE major objective of this research is to find a basis for improvement in methods of teaching. Teachers have been quite subjective in determining the frequency of practices in the teaching of motor skills or other school subjects. Only a few research efforts have been reported on the subject of time psychology. The old adage "practice makes perfect" seems to have much less meaning in the light of present research. The length of time intervals between practice periods may prove to be just as important as the length of practice periods.

The unique phase of this research is the inclusion of a time pattern that has not been used in other research, and which is found significantly more advantageous than the other three patterns used. The unique time pattern is herein called the additive pattern. It should be noted that this pattern follows a five-eight ratio and is suggested or borrowed from the field of botany. The relationship to botany is through philotaxy, which is a law of growth of plants involving a five-eight ratio.

More and more psychologists are concluding that the learning process is a neurological growth process, therefore, more research should be encouraged in which the known laws of growth, or related factors, are applied to learning situations. In the opinion of the authors, the field of physical education offers excellent laboratories for research in which major contributions may be made that are important to all fields of education, and especially in studies of the learning process.

This research is upon the level of basic or beginning skills, in which problems of reliability of performance may be solved or better understood. One follow-up study herein reported by Lawrence (11) indicates that reliability may be determined, at least in part, by the time pattern upon which basic or beginning skills are learned.

Other research is going forward in which studies are being made of the most efficient time patterns for coaching the various sports. In other words, how long are optimum practice periods in various sports and upon what days of the week in relation to scheduled contest? Such questions may possibly be answered through experimental research in time psychology.

## EXPERIMENT IN TIME PSYCHOLOGY

Physical education includes many skills which lend themselves to research in the field of time psychology due to the fact that they can be

isolated, controlled and evaluated while maintaining the interest of the subjects.

Billiards was used as the motor skill to be learned because set shots could be standardized for use by all subjects, the table could be made available to all participants and an interest created and maintained in the experiment.

College women who had had no previous experience in playing pool or billiards were used as subjects for the experiment. The players were divided into four groups. The units of practice, number of practices and length of practice periods were kept constant for all groups. The time intervals between the practice periods were varied for each of the four groups and produced the following time patterns:

1. The first group carried on their nine practice sessions three days per week for three weeks in a row—i.e., Monday, Tuesday, Wednesday of the first week, Monday, Tuesday, Wednesday of the second week and Monday, Tuesday, Wednesday of the third week. Listing the days by numbers gives the following practice days: 1st day, 2nd, 3rd, 8th, 9th, 10th, 15th, 16th, 17th. This group was called the *Three-Day-Per-Week-Group.*

2. The second group carried on their practice periods on an additive basis—i.e., adding the first two numbers or days to make the third number or day (first day plus second day equals third day); the second and third numbers or days to make the fourth number or day, etc., up to and including the fifty-fifth day which was the ninth practice session. Listing the nine practice periods by numbers, gives days on which the practices occurred: 1st day, 2nd, 3rd, 5th, 8th, 13th, 21st, 34th, 55th. This group was called the *Additive-Group.*

3. Practice for the next group was conducted on a daily basis including Saturday and Sunday. The time pattern may be described as follows: 1st day, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th. This group was called the *Daily-Group.* From a relative point of view this group most nearly approached massed learning as far as this experiment was concerned.

4. The last time pattern was established on the basis of practice once per week. The number of the nine respective days when the practice periods were conducted include: 1st day, 6th, 15th, 22nd, 29th, 36th, 43rd, *, 57th, 64th. The exception (*) to the one day per week schedule was made between the seventh and eighth practice periods because of vacation week. The group was called the *One-Day-Per-Week-Group.*

A group of set shots were developed by the authors and tried out by two women subjects who had never played billiards or pool. During this testing period, which was conducted over a period of two months, eleven set shots were established and arranged more or less progressively in their order of difficulty. The first five of the eleven set shots were then selected for the first practice period. Number one set shot was attempted five times on the right side of the table. The same set shot was repeated on the left side of the table. This procedure was carried on with set shots two, three, four, and five, thus making a total of fifty shots per practice period. During each

succeeding practice period, a new shot was added while dropping the first set shot of the previous practice. This procedure was carried on until all eleven set shots were used.

One exception to this procedure was the retention of one set shot for all practice periods. A constant was thus provided to show the effect of time on learning a single set shot.

The first practice period was used for instruction. Starting with the second practice period and continuing on throughout the ninth practice session, no corrective suggestions were given.

### ANALYSIS OF THE DATA

The scores from the second practice period were selected as the basis for equating the four groups. These scores are presented in Tables 1 and 2.

TABLE 1

*Summary of the data for the second practice period for the four groups*

| GROUPS | NUMBER | RANGES | MEANS | S.D. |
|---|---|---|---|---|
| I—Three day per week | 18 | 19–41 | 29.2 | 6.96 |
| II—Additive | 18 | 20–40 | 29.1 | 6.85 |
| III—Daily | 18 | 17–43 | 29.3 | 7.41 |
| IV—One day per week | 18 | 18–42 | 29.2 | 6.92 |

TABLE 2

*Correlation coefficients between groups*

| GROUPS | CORRELATION COEFFICIENTS | GROUPS | CORRELATION COEFFICIENTS |
|---|---|---|---|
| I–II | 0.986 | II–III | 0.955 |
| I–III | 0.981 | II–IV | 0.955 |
| I–IV | 0.973 | III–IV | 0.989 |

At the end of the experiment the statistical differences between the four groups were determined. A critical ratio of 2.50 (approximately the 1% level) was considered indicative of a statistically significant difference. Table 3 shows the differences in the mean scores for the four groups for the last practice period.

1. The results of the three consecutive days per week pattern (group I) were inferior to those of the additive pattern. However, it produced better results than the daily and the one day per week patterns, respectively, but the differences were not statistically significant.

2. The additive time interval pattern (group II) produced the best results. There were statistically significant differences in the mean gains and resulting critical ratios of this group over those of the other three groups.

3. The results of the daily time pattern (group III) were better (but not

statistically significantly better) than those for the one day per week time pattern (group IV) but inferior to the results of the other two patterns.

4. The one day per week pattern (group IV) proved to be the poorest of the four patterns.

5. The results of the one set shot which was used in all practice periods for the four groups were similar to the results of all set shots for the groups. In other words, as far as results were concerned, the research might have been limited to one set shot for all four groups.

TABLE 3

*Difference in means between the four groups for the ninth practice period*

| GROUP PRACTICE | NO. | M | S.E. | Dmlm2 | S. E.d | C. R. |
|---|---|---|---|---|---|---|
| I | 18 | 31.6 | 1.26 | 3.0 | 1.20 | 2.50 |
| II | 18 | 34.6 | 0.88 | | | |
| I | 18 | 31.6 | 1.26 | 1.0 | 1.50 | 0.66 |
| III | 18 | 30.6 | 1.33 | | | |
| I | 18 | 31.6 | 1.26 | 2.0 | 1.56 | 1.28 |
| IV | 18 | 29.6 | 1.06 | | | |
| II | 18 | 34.6 | 0.88 | 4.0 | 1.48 | 2.71 |
| III | 18 | 30.6 | 1.33 | | | |
| II | 18 | 34.6 | 0.88 | 5.0 | 1.38 | 3.63 |
| IV | 18 | 29.6 | 1.06 | | | |
| III | 18 | 30.6 | 1.33 | 1.0 | 1.47 | 0.68 |
| IV | 18 | 29.6 | 1.06 | | | |

CONCLUSIONS

1. There were no statistically significant differences between the patterns through the sixth practice period. Significant differences thereafter occurred and were probably due to the various time patterns used from the beginning of the experiment. Therefore, in conducting research in this field, practices should be carried on beyond six practice periods.

2. There were no statistically significant differences in the final results between the nine consecutive days pattern, the three consecutive days per week for three weeks pattern and the pattern of one day per week for nine weeks.

3. There were statistically significant differences in the final results in favor of the additive pattern over the other three patterns.

4. A good base or foundation should be established in learning a new skill such as billiards. Relative massing at the beginning of the learning process is to be preferred over widely spaced time intervals at the beginning. From three to five practice periods were found satisfactory for establishing beginning skills.

5. After the foundation has been laid, greater spacing between practice periods has a more favorable effect upon learning than continued massing.

6. Progressively lengthening the time intervals between the practice periods (the additive pattern) proved beneficial in learning a new motor skill. The additive pattern may not be the best time pattern to be used in learning, but should be considered as a point of reference from which further research may be undertaken in finding such a pattern.

## FURTHER RESEARCH

In a follow-up study Longley (12) used a "Massed-evenly spaced" time pattern (1, 2, 3, 8, 15, 22, 29, 36, 43) which, when compared with Miller's (15) four time patterns gave the following results:

The improvement of the "Massed-evenly spaced" group (Longley's) was slightly inferior to the Additive group (Miller's group II), although the result was not statistically significant. There were statistically significant differences in favor of the "Massed-evenly spaced" group over Miller's other three groups—i.e., Daily group, Three day per week group, and One day per week group. These results were similar to the Additive-Group's statistically significant superiority over the other three groups.

The results of these two studies seem to indicate that some form of a massed spaced time pattern should be used in learning a new motor skill.

Lawrence (11), using over sixty per cent of the subjects used in the original study, made a reliability check of the Additive group (Miller's group II) and the Daily group (Miller's group III). The check was to be considered indicative of the degree of retention between the two groups.

The results of the study showed a statistical significance (a critical ratio of 2.87) in favor of the Additive group over the Daily group.

A conclusion which may be drawn from this study is that the retention in a massed-interpolated-spaced learning pattern (Additive group) was superior to the retention in a massed learning pattern (Daily group). Further research should be conducted before any final conclusions may be made as all of the original subjects were not used in the reliability check.

There are many unsolved problems in the field of time psychology, some of which are now in the process of being solved by other research workers.

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# The Effect of Systematic Weight Training on Athletic Power

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MANY PEOPLE, including those directly as well as those indirectly related to physical education and athletics, believe that weight training may be detrimental to the participant. Very frequently, in the classroom, on the gymnasium floor, and on the athletic field, the term "weight training" is associated with "muscle-boundness," a condition supposedly resulting in a general slowing down of the contraction speed of the muscular system. No scientific evidence, however, has been advanced to support these beliefs. This study was undertaken to ascertain some of the pertinent facts concerning the effects of systematic weight training on athletic power.

Weight training, as considered in this treatise, refers to a systematic, well-planned program of exercises in which the participant uses weights, barbells and dumbbells, to increase the resistance of various bodily movements. This type of exercise with weights is contrasted with the competitive type usually referred to as "weight lifting." In weight lifting the competitor endeavors to raise a maximum weight in a single lift, whereas in weight training the participant executes many consecutive repetitions of each exercise with a weight which has been found to be compatible with his strength and endurance. In competition, there are only three prescribed lifts, the Olympic lifts, namely, the "Press," the "Snatch," and the "Clean and Jerk." In weight training, the exercises and the weights are selected in accordance with the participant's objective, and in accordance with his present strength and endurance.

## Experimental Procedure

*Subjects.* Two groups of subjects were used in this study. One group of twenty-three subjects performed the weight training exercises, which are outlined below, two to three times a week for one hour each period. This group of subjects will be referred to hereafter as Group A. The other group, which was composed of twenty-two subjects, did no weight training exercises, but participated in the required physical-education program of the State University of Iowa. This latter group of subjects will be referred to hereafter as Group B. The subjects of Group A were students who had engaged in very little or no weight training up to the time of this experi-

ment, and ranged in age from seventeen to thirty-two years. The subjects of Group B were freshmen and sophomores from seventeen to nineteen years of age.

### Data

The following data were secured from both groups at the beginning and at the end of the three-month training period:

1. Body weight
2. Sargent jump—standing
3. Sargent jump—running
4. Standing broad jump
5. Eight-pound shot-put from a stand
6. Twelve-pound shot-put from a stand
7. Sixty-yard sprint

Each subject was given individual instruction in the various tests, and practiced until he could perform the tests to the satisfaction of the experimenter. The test items were administered to each subject on three different days, and the best performance in each test was taken as the record in each event. The body weight was recorded on the first test day. This plan was followed during the initial test and also during the final test at the end of the three-month period. All the subjects were instructed not to practice these test items during the three-month period.

The inclusion of these six performance tests in the testing criterion was based on the thesis that power (the time rate of doing work, or, force times velocity), when applied by the human body, is the essential mechanical factor in the projection of the individual's own body or of some other mass rapidly through space. All these events—sprinting, jumping, and throwing —require maximum, or nearly maximum, muscle contractions in a minimum of time, and have been well substantiated as valid test items for measuring power (2, 4).

*Weight Training Exercises.* The following exercises were employed in this study (1):

*Barbell Exercises*

1. High pull-up
2. Two-arm curl
3. Side bend
4. Two-arm press
5. Repetition snatch
6. Stiff leg dead lift
7. Supine press
8. Straddle hop
9. Repetition clean and jerk
10. Squat (alternated with squat jump)

*Dumbbell Exercises*

1. Squat jump (alternated with squat)
2. Forward raise
3. Pull-over
4. (a) Lateral raise (standing)
   (b) Lateral raise (trunk bent forward)
5. Supine lateral raise
6. Sit-up

The subjects individually followed this plan of exercise. Each exercise was performed from eight to twelve repetitions. The sit-up exercise was performed from fifteen to twenty-five repetitions. Each individual subject used a weight with which he could correctly perform the exercise eight times and continued using this weight until he could do twelve repetitions without undue distress. Then the weight was increased and the eight-to-twelve repetition plan was repeated. In the exercises with the barbell, one weight (in general, about 70 pounds) was used for exercises 1, 2, and 3. A second, heavier weight (in general, about 100 pounds) was used for exercises 4, 5, and 6. A third, heavier weight (in general, about 125 pounds) was used for exercises 7, 8, 9, and 10. Some individuals were able to use a heavier weight for exercise 10 than that which was used for exercises 7, 8, and 9. In the exercises with the dumbbells, the weight used (in general, about 15 pounds) was the same for all five exercises. There were a few individuals who were able to use a dumbbell heavier by about five pounds for exercise 2. In the sit-up exercise, a weight was used for 15 repetitions and was not increased until 25 repetitions could be performed. In general, the subjects used from 5 to 20 pounds in this exercise.

## RESULTS

The data obtained from the subjects of both groups are summarized in the following tables. The figures presented in Tables 2–7 would seem to the writer to justify the statements made following the appropriate tables, concerning the effects of systematic weight training on athletic power.

*Power as Related to Jumping.* The results of the standing Sargent jump test showed that the mean improvement was 7.2 cm.[1] The gains varied from 1 cm. to 12 cm. All the subjects showed an improvement in this test.

The results of the running Sargent jump test showed an average improvement of 7.6 cm. The range in improvement varied from 1 cm. to 14 cm. Twenty-two subjects showed gains and one subject showed no difference.

The results of the standing broad jump test showed an average improvement of .3 of a foot. However, of the twenty-three subjects tested, twenty-one showed an improvement ranging from $\frac{1}{2}$ inch up to $10\frac{1}{4}$ inches, while one subject showed a loss of 1 inch and one subject showed a loss of $2\frac{1}{2}$

[1] The figures used here in the discussion of the findings together with the implications drawn from them, all refer to Group A. There was no significant improvement in Group B.

TABLE 1

*Body weight (pounds)*

| GROUP A | | GROUP B | |
|---|---|---|---|
| Means of body weights | | Means of body weights | |
| Initial test | 157.3 | Initial test | 146.8 |
| Final test | 160 | Final test | 149 |
| Mean of gains among those who gained weight | 4.5 | Mean of gains among those who gained weight | 3.8 |
| Mean of losses among those who lost weight | 2.2 | Mean of losses among those who lost weight | 2.5 |

The differences or changes recorded in body weight ranged from a gain of 13 pounds to a loss of 4 pounds for Group A, and from a gain of 7 pounds to a loss of 3 pounds for Group B.

TABLE 2

*Sargent Jump—standing (centimeters)*

| GROUP A | | GROUP B | |
|---|---|---|---|
| Means of jumps | | Means of jumps | |
| Initial test | 52.4 | Initial test | 53.36 |
| Final test | 59.6 | Final test | 53.26 |
| Mean of gains among those who gained | 7.2 | Mean of gains among those who gained | 3.86 |
| No losses were recorded | | Mean of losses among those who lost | 2.14 |

The difference in performances recorded for each subject ranged from a gain of 1 to 12 centimeters for Group A, and from a gain of 8 centimeters to a loss of 4 centimeters for Group B.

TABLE 3

*Sargent Jump—running (centimeters)*

| GROUP A | | GROUP B | |
|---|---|---|---|
| Means of jumps | | Means of jumps | |
| Initial test | 56 | Initial test | 56.9 |
| Final test | 63.6 | Final test | 55.9 |
| Mean of gains among those who gained | 8 | Mean of gains among those who gained | 2.88 |
| No losses were recorded | | Mean of losses among those who lost | 3.18 |

The difference in performances recorded for each subject ranged from no difference to a gain of 14 centimeters for Group A, and from a gain of 8 centimeters to a loss of 7 centimeters for Group B.

inches. Among the twenty-one subjects who did show an improvement, the mean improvement was 3.99 inches.

TABLE 4

*Standing Broad Jump (feet and inches)*

| GROUP A | | GROUP B | |
|---|---|---|---|
| Means of jumps | | Means of jumps | |
| Initial test | 7.5 ft. | Initial test | 7.15 ft. |
| Final test | 7.8 ft. | Final test | 7.14 ft. |
| Mean of gains among those who gained | 3.99 in. | Mean of gains among those who gained | 2.375 in. |
| Mean of losses among those who lost | 1.75 in. | Mean of losses among those who lost | 2.885 in. |

The difference in performances recorded for each subject ranged from a gain of 10.25 inches to a loss of 2.5 inches for Group A, and from a gain of 4.25 inches to a loss of 7 inches for Group B.

TABLE 5

*Eight-pound Shot-Put (feet and inches)*

| GROUP A | | GROUP B | |
|---|---|---|---|
| Means of puts | | Means of puts | |
| Initial test | 33.33 ft. | Initial test | 31.184 ft. |
| Final test | 36.32 ft. | Final test | 31.6 ft |
| Mean of gains among those who gained | 2.98 ft. | Mean of gains among those who gained | 2.23 ft. |
| No losses were recorded | | Mean of losses among those who lost | 1.91 ft. |

The difference in performances recorded for each subject ranged from a gain of 5 feet $\frac{3}{4}$ inch to 1 foot $1\frac{3}{4}$ inches for Group A, and from a gain of 5 feet 11 inches to a loss of 5 feet 10 inches for Group B.

TABLE 6

*Twelve-pound Shot-Put (feet and inches)*

| GROUP A | | GROUP B | |
|---|---|---|---|
| Means of puts | | Means of puts | |
| Initial test | 27.18 ft | Initial test | 25.12 ft. |
| Final test | 29.5 ft. | Final test | 25.7 ft. |
| Mean of gains among those who gained | 2.37 ft. | Mean of gains among those who gained | 1.41 ft. |
| No losses were recorded | | Mean of losses among those who lost | 10.34 in. |

The difference in performances recorded for each subject ranged from a gain of 6 inches to 4 feet $9\frac{3}{4}$ inches for Group A, and from a gain of 3 feet 5 inches to a loss of 2 feet for Group B.

The data obtained from these jumping tests indicate that systematic weight training as outlined in this study has a decidedly positive effect on jumping power.

*Power as Related to the Shot-Put.* The results of the eight-pound shot-put test showed a mean improvement of 2.98 feet or 2 feet 11¾ inches.[2] The gains varied from 1 foot 1¾ inches to 5 feet ¾ inch. All of the subjects tested showed an improvement.

The results of the twelve-pound shot-put test were similar to those of the eight-pound shot-put test. The mean improvement was 2.37 feet or 2 feet 4½ inches, with the gains varying from 6 inches to 4 feet 9¾ inches. All of the subjects tested showed an improvement.

The data obtained from these shot-put tests show that systematic weight training as outlined in this study has a positive effect on power involved in the shot-put.

*Power as Related to Sprinting.* The results of the sixty-yard dash showed that of the twenty-two subjects tested, seventeen showed an improvement, four showed no difference, and one ran slower by 0.1 of a second.[3] Of the seventeen who ran faster, the mean improvement was 0.33 of a second, with the gains in speed varying from 0.1 of a second to 0.6 of a second.

These results indicate the probability of increasing speed through training with systematic weight training exercises.

TABLE 7

*Sixty-yard Dash (seconds)*

| GROUP A | | GROUP B | |
|---|---|---|---|
| Means of times | | Means of times | |
| Initial test | 7.9 | Initial test | 8.05 |
| Final test | 7.57 | Final test | 8.1 |
| Mean of gains in speed among those who ran faster | 0.33 | Mean of gains in speed among those who ran faster | 0.16 |
| Loss in speed for one subject who ran slower | 0.1 | Mean of losses in speed among those who ran slower | 0.18 |

The difference in performances recorded for each subject ranged from a gain of 0.6 of a second to a loss of 0.1 of a second for Group A, and from a gain of 0.2 of a second to a loss of 0.4 of a second for Group B.

## GENERAL INDICATIONS

The data obtained from this study and the implications drawn from the data indicate that the subjects of Group A seemed to increase the amount of potential power through systematic weight training exercises, whereas,

[2] The figures used here in the discussion of the findings together with the implications drawn from them, all refer to Group A. There was no significant improvement in Group B.

[3] The figures used here in the discussion of the findings together with the implications drawn from them, all refer to Group A. There was no significant improvement found in Group B.

the subjects of Group B did not show such consistent increases. Power, being force times velocity, in the human body is apparently limited by the muscular viscosity (3). The greater the speed of contraction, the more force is required to overcome the viscosity of the muscles. With an increase in strength, however, more force can be used to overcome the viscosity of the muscle, and to force the maximum velocity to higher levels.

This study concerned itself solely with the effect of weight training on athletic power, and no data were presented relating to improvements in actual strength, in muscular endurance, or in circulorespiratory endurance.

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# Extra Pay for Extra Services

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WHAT is the present policy and practice regarding compensation for extra services in the high schools of New York State? To discover the answer to this question a questionnaire was sent to all city superintendents, village superintendents and to all central school principals[1] in the State. It is hoped that the findings will be of help to the schools in New York State and other states which have not yet set up such policies and practices or who are planning to revise their present system.

Fifty-two[2] replies were received from the 62 city superintendents, 76 from the 100 village superintendents and 279 from the 346 central schools. This represents a return of 84, 76 and 81 per cent respectively.

The following questions were asked:

1. What is the policy of your school (or school system) with regard to compensation for extra services? *Check correct answer*
   (1) Load compensation—no salary differential .....
   (2) Extra pay schedule for extra services .....
   (3) Included in basic salary (e.g. regular salary for other teachers, $2400, for physical education teachers $2800) .....
   (4) No pay or load differential .....
   (5) Others (please explain) .....

   *Please enclose copy of policy and/or pay schedule if available*

2. If there is extra pay what is the source?
   (1) Board of Education funds .....
   (2) Athletic Fund (gate receipts) .....
   (3) Others (list and explain—e.g. receipts from school play) .....

[1] City and village superintendencies are difficult to define adequately. The cities are such by their charter and in general are larger than villages although there is considerable overlap. A village superintendency is a superintendency in a village of over 4500 population as determined by the Commissioner of Education. Village lines and village superintendencies may or may not coincide. Central School Districts can be compared to consolidated schools in other states.

[2] Only 50 answers in this group actually were tabulated due to inadequately filled out questionnaires in two cases. Therefore 50 will be used instead of 52 in the rest of the study.

3. Supervision of which school activities carry extra pay? *Insert amount of yearly compensation below*

(1) Club activities (e.g. dramatics, band, yearbook—list names below) .....

.....

(2) Intramurals .....
(3) Interscholastic sports (list below) .....
(4) Other activities (list as in the above) .....

.....

4. Please add here any information not already listed that will help us to understand more fully your system of compensation for extra services.

Chart I is a summary of the answers received to the first question—what is the policy of your school, or school system, with regard to compensation for extra services? With a few exceptions the answers indicated

CHART I

*School policy regarding compensation for extra services*

| | CITY SUPERINTENDENTS | VILLAGE SUPERINTENDENTS | CENTRAL SCHOOLS ADMINISTRATORS | TOTAL OF THESE GROUPS |
|---|---|---|---|---|
| | 50 (total answering) | 76 (total answering) | 279 (total answering) | 405 (total answering) |
| (1) Load compensation—no salary differential | 6 (12%) | 6 (8%) | 57 (20%) | 69 (16%) |
| (2) Extra pay schedules for extra services | 21 (42%) | 29 (38%) | 32 (11%) | 82 (20%) |
| (3) Included in basic salary | 5 (10%) | 13 (17%) | 98 (35%) | 116 (28%) |
| (4) No pay or load compensation | 4 (8%) | 7 (9%) | 52 (19%) | 63 (16%) |
| (5) Some combination of the above four | 14 (28%) | 21 (28%) | 40 (15%) | 75 (19%) |

clearly the policies of the individual schools. The superintendent of one city school indicated a combination of load compensation—no salary differential and no pay or load differential! The only plausible explanation for this seeming inconsistency is that some people are treated in a different manner than others revealing that there is no real policy except one of expediency.

A few village superintendents also indicated incompatible combination policies. In at least one instance this was explained by a transition from one policy to another in regard to extra pay. As the new policy was not made retroactive a temporary dichotomy of practice exists. There were also a few apparent inconsistencies in the policies reported by the central school principals.

The one striking difference in policy discovered in the study was that city and village schools in New York State are much more likely to have extra pay schedules for extra services than are central schools—42 and 38 per cent respectively as compared to 11 per cent. Conversely, central schools are much more likely to include extra pay for extra services in the

basic salary—35 per cent as compared to 10 and 17 per cent for the city and village superintendents.

Chart II is a summary of the answers received to the second question—If there is extra pay what is the source?

Some very interesting and unusual extra pay for extra duty items appear in Chart IV. A few of these and the salary increment provided yearly are:

| | |
|---|---|
| Detention Master | $175 |
| Cheerleader Director | $75–$150 |
| Alumni and Former Student Relations | $100 |
| Bus Starter | $100–$200 |
| Head of Family with Dependents | $500 |

CHART II

*Source of extra pay*

| | CITY SUPERINTENDENTS | VILLAGE SUPERINTENDENTS | CENTRAL SCHOOL ADMINISTRATORS | TOTAL OF THREE GROUPS ANSWERING |
|---|---|---|---|---|
| | 36 (total answering) | 49 (total answering) | 80 (total answering) | 165 (total answering) |
| (1) Board of Education Funds | 33 (91%) | 48 (98%) | 75 (94%) | 156 (94%)* |
| (2) Athletic Fund (gate receipts) | 1 (3%) | 1 (2%) | 1 (1%) | 3 (2%) |
| (3) Others (list and explain—e.g. receipts from school play) | | | | |
| Combination of (1) and (2) | 2 (6%) | | 3 (4%) | 5 (3%) |
| City recreation funds | | | 1 (1%) | 1 (1%) |

* Because of the very large number of schools returning questionnaires without answering this question (64%) the results may not represent the actual situation in the schools of the state as a whole.

Two items of interest gleaned from the answers to question four—any additional information that would help in understanding a particular school's system of compensation for extra service—were:

(1) Several schools mentioned that they were paying extra for junior high school sport coaching although no such break down was requested in the questionnaire.

(2) One school stated that it paid a flat $2.50 per hour for services beyond a normal load (normal load was defined as 5 classes daily plus 75 hours extra-curricular work for academic teachers, 5 classes plus 200 hours for art, music and shop teachers, and 5 classes plus 350 hours of extra curricular activities for physical education teachers!).

(3) One village school indicated a policy of granting a family allowance and stated that extra services had been volunteered by the recipients of these benefits.

## CHART III

*Range and median of extra pay reported for various activities*

| | CITY SUPERINTENDENTS (50 TOTAL ANSWERING) | | VILLAGE SUPERINTENDENTS (76 TOTAL ANSWERING) | | CENTRAL SCHOOL ADMINISTRATORS (279 TOTAL ANSWERING) | | TOTAL OF THREE GROUPS (405 TOTAL) | |
|---|---|---|---|---|---|---|---|---|
| | Number reporting extra pay for this activity | Salary reported (median indicated below range) | Number reporting extra pay for this activity | Salary reported (median indicated below range) | Number reporting extra pay for this activity | Salary reported (median indicated below range) | Number reporting | Salary range (median indicated below range) |
| 1. Athletic administration (director, accounts, equipment, game and ticket managers) | 11 (22%) | $100–900 Median 325 | 7 (9%) | $4.00 per game –250 annual Median 150 | 7 (3%) | $50–300 Median 200 | 25 (6%) | $4.00 per game –900 annual Median 225 |
| 2. Baseball (head-coach, assistant, junior varsity and freshman) | 33 (66%) | $2.00 per hour –350 annual Median 200 | 33 (43%) | $100–300 Median 200 | 35 (13%) | $75–300 Median 150 | 101 (25%) | $2.00 per hour –$350 annual Median 200 |
| 3. Basketball | 44 (88%) | $100–750 Median 300 | 38 (50%) | $100–500 (1 listed $100 for coaching women's basketball) Median 200 | 51 (18%) | $100–400 Median 200 | 133 (33%) | $100–750 Median 250 |
| 4. Bowling | 3 (6%) | $50–100 Median 100 | 6 (8%) | $50–150 Median 100 | 5 (2%) | $100–150 Median 150 | 14 (3%) | $50–150 Median 100 |
| 5. Coaching (general or several sports listed e.g. minor sports, football, baseball and track | 4 (8%) | $100–800 Median 600 | 15 (20%) | $100–800 Median 300 | 26 (9%) | $50–900 Median 300 | 45 (11%) | $50–900 Median 300 |
| 6. Cross Country | 5 (10%) | $50–150 Median 125 | 5 (7%) | $100–150 Median 125 | 4 (1%) | $100–175 Median 150 | 14 (3%) | $50–175 Median 135 |
| 7. Dramatics (also includes debate and public speaking | 8 (16%)* | $100–300 Median 200 | 6 (8%) | $50–200 Median 100 | 11 (4%) | $50–500 Median 100 | 25 (6%) | $50–500 Median 100 |
| | 4 (8%)† | $25–100 (per play) Median 75 | 1 (1%) | $75 | 2 (0.7%) | $50–100 Median 85 | 7 (2%) | $25–100 Median 75 |
| 8. Extra Curricular | 3 (6%) | $200 | 1 (1%) | $150 | 7 (3%) | $100–300 Median 150 | 11 (3%) | $100–300 Median 200 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| public speaking | 4 (8%)† | $25–100 (per play) Median 75 | 1 (1%) | $75 | 2 (0.7%) | $50–100 Median 85 | 7 (2%) | Median 100 $25–100 Median 75 |
| 8. Extra Curricular Activities, (social, general organization service squads, assemblies) | 3 (6%) | $200 | 1 (1%) | $150 | 7 (3%) | $100–300 Median 150 | 11 (3%) | $100–300 Median 200 |
| 9. Football (head, junior varsity, assistant, freshman and touch football coach) | 50 (100%) | $125–1500 Median 300 | 46 (61%) | $100–700 Median 200 | 35 (13%) | $75–700 Median 185 | 131 (32%) | $75–1500 Median 250 |
| 10. Golf | 5 (10%) | $50–125 Median 100 | 6 (8%) | $50–100 Median 100 | 4 (1%) | $50–175 Median 135 | 15 (4%) | $50–175 Median 100 |
| 11. Hockey: Ice | 2 (4%) | $100–300 | 2 (3%) | $100–250 | | | 4 (1%) | $100–300 Median 175 |
| Field (Women) | | | 1 (1%) | $100 | | | 1 (0.2%) | $100 |
| 12. Intramurals (including noon time recreation, play grounds, and scouts—both boys & girls) | 20 (40%) | $1.25 per hour –400 annual Median 165 | 12 (16%) | $2.00 per hour –475 annual (1 listed 100 per sport) Median 200 | 12 (4%) | $100–250 Median 100 | 44 (13%) | $1.25 per hour–475 annual Median 150 |
| 13. Lacrosse (head, assistant, junior varsity and freshman coach) | | | 6 (8%) | $100–350 Median 150 | | | 6 (1%) | $100–350 Median 150 |
| 14. Music Activities (band, orchestra, instrumental, choral and combinations) | 8 (16%) | $50–500 Median 200 | 5 (7%) | $200–500 Median 200 | 14 (5%) | $60–600 Median 200 | 27 (7%) | $50–600 Median 200 |
| 15. Publications (paper and yearbook) | 14 (28%) | $75–200 Median 100 | 24 (32%) | $50–300 Median 125 | 23 (8%) | $75–350 Median 150 | 61 (15%) | $50–350 Median 100 |
| 16. Rifle | | | 3 (4%) | $100 Median 100 | 2 (0.7%) | $100–300 | 5 (1%) | $100–300 Median 100 |
| 17. Skiing | 1 (2%) | $75 | | | | | 1 (0.2%) | $75 |
| 18. Soccer (head, assistant, junior varsity and freshman) | 3 (6%) | $50–250 Median 200 | 8 (11%) | $100–250 Median 175 | 8 (3%) | $100–225 Median 150 | 19 (5%) | $50–250 Median 175 |

CHART III—*Continued*

| | CITY SUPERINTENDENTS (50 TOTAL ANSWERING) | | VILLAGE SUPERINTENDENTS (76 TOTAL ANSWERING) | | CENTRAL SCHOOL ADMINISTRATORS (279 TOTAL ANSWERING) | | TOTAL OF THREE GROUPS (405 TOTAL) | |
|---|---|---|---|---|---|---|---|---|
| | Number reporting extra pay for this activity | Salary reported median indicated below range) | Number reporting extra pay for this activity | Salary reported (median indicated below range) | Number reporting extra pay for this activity | Salary reported (median indicated below range) | Number reporting | Salary range (median indicated below range) |
| 19. Softball | | | 1 (1%) | $150 | 1 (0.4%) | $100 | 2 (0.5%) | $100–150 |
| 20. Supervision of Special Events (ticket sellers and takers, announcers, stage attendants, assistant ticket manager, auditorium director) | 5 (10%) | $2.00 per event–200 annual Median 200 (4 paid by event) | 6 (8%) | $2.00 per hour–300 annual Median 290 (4 paid by event) | 5 (2%) | $2.00 per hour–250 annual Median 200 (2 paid by event) | 16 (4%) | $2.00 per hour–300 annual Median 225 (10 paid by event) |
| 21. Swimming (head and assistant coach) | 9 (18%) | $100–300 Median 185 | 1 (1%) | $100 | 1 (0.4%) | $275 | 11 (3%) | $100–300 Median 185 |
| 22. Tennis | 10 (20%) | $50–150 Median 100 | 10 (13%) | $50–300 Median 100 | 8 (3%) | $50–200 Median 100 | 28 (7%) | $50–300 Median 100 |
| 23. Track (head, assistant, junior varsity and freshman coach) | 35 (70%) | $50–350 Median 200 | 23 (30%) | $100–250 Median 200 | 18 (6%) | $50–200 Median 150 | 76 (19%) | $50–350 Median 200 |
| 24. Wrestling | 2 (4%) | $100–200 Median 150 | 3 (4%) | $100–150 Median 100 | 4 (1%) | $100–300 Median 225 | 9 (2%) | $100–300 Median 150 |

* Number and salaries reported on yearly basis.
† Number and salaries reported per play.

This study did not attempt to establish what is desirable policy or practice but the authors are convinced that teaching services should not be contracted for piecemeal and that negotiations should be on the basis of arriving at a salary which covers all the duties of a particular teacher. *This should not be interpreted to mean that extra duties should be added to a teachers load without an increase in base pay or that certain teachers should have greater responsibilities without added remuneration.*

CHART IV

*Miscellaneous Headings**

| | NUMBER REPORTING | SALARY RANGE AND MEDIAN |
|---|---|---|
| 1. Administration (general) head of department, secondary school vice principal, assistant to the principal | 16 (4%) | $100–1200 Median 200 |
| 2. Attendance (census) | 6 (1%) | $100–200 Median 100 |
| 3. Cafeteria (manager-cashier) | 5 (1%) | $100–200 Median 200 |
| 4. Fund administrator (treasurer extra funds, controller, extra class funds, fund auditor) | 27 (7%) | $50–600 Median 150 |
| 5. Advisors (class, club) | 32 (8%) | $25–250 Median 100 |
| 6. Guidance and Counseling | 6 (1%) | $100–500 Median 225 |
| 7. Head of family with dependents | 1 (0.2%) | $500 |
| 8. Services (book store, shop maintenance, lab maintenance, work on athletic field, art department services, bus starter or driver) | 15 (4%) | $84–700 (some listed hourly pay rate) Median 125 |
| 9. Special jobs (alumni and former student relations, testing, detention master, cheerleaders, morning study hall, photography) | 8 (2%) | $75–400 (some listed hourly pay rate) Median 150 |
| 10. Special teaching (industrial arts, girls physical education, driver training, agricultural supervision and agricultural projects) | 9 (2%) | $100–700 Median 200 |
| 11. Supervision adult and evening education | 15 (4%) | $2.00 per hour 600 annually Median 250 |
| 12. Visual education | 4 (1%) | $75–300 Median 150 |

* Only totals for the three groups and total salary ranges are given.

The following conclusions in regard to the New York State Schools surveyed seem justified on the basis of the findings of this questionnaire:

(1) Practically all schools have some type of extra pay for extra service policy but both policy and/or practice is confused or chaotic in many instances and even contradictory in a few.
(2) The program of extra pay for extra services has been carried so far in individual school systems that in some instances all duties outside of actual class meetings seem to have been contracted for on an

individual piecemeal basis! This may be accounted for partially by an administrative attempt to provide salary increases where boards were unwilling to increase basic salary schedules, although no direct evidence of this was uncovered by the study.

(3) City and village schools are much more likely to have extra pay schedules for extra services than are central schools—42 and 38% respectively as compared to 11%.

(4) Apparently central schools have gone much further toward a solution to this problem than the village and city schools, since they are much more likely to include extra pay in a basic salary—35% as compared to 10 and 17%—or if there is no salary differential they are more likely to give load compensation—20% as compared to 12 and 8%.

(5) Practically all schools—94%—indicate the source of extra pay funds was the board of education. However, only about one third of the schools replying answered this question. This figure may not, therefore, represent the actual situation in the schools of the state as a whole.

(6) Apparent inconsistency in policy and practice within some school systems is explained by a change of policy which was not made retroactive.

(7) Less than 2% of the schools replying stated that extra pay came exclusively from gate receipts and only 2.5% reported a combination of gate receipts and Board of Education Funds. One school reported use of city recreation funds for this purpose. Therefore, only 9 schools out of 165 reported deviation from the generally accepted practice of financing extra duties from Board of Education funds.

(8) The only instance where all schools reporting gave extra pay for extra service was in city superintendencies for coaching football. Basketball was a close second with 88% of the same group reporting extra pay.

# Bilateral Effects of Muscle Activity

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THE TRANSFER effects of systematic exercise of muscles in one part of the body upon muscles in another part of the body has been the concern of a number of investigations. One of the earliest of these studies appears to be that of Scripture (6) at the Yale Psychological Laboratory. In this study it was found that exercise of one hand with a dynamometer resulted in an increment of muscular performance of the other hand. In a second study, conducted in the same laboratory, Davis (4) reported that systematic exercise with dumbbells, a dynamometer, and ergograph in one part of the body markedly influenced the muscular performance in other parts of the body. It was also noted that the exercise effects were greatest in symmetrical and related parts.

Wissler and Richardson (7) reported that daily exercise of pulling on a dynamometer with one arm increased muscular performance in the accessory muscle of that arm (muscles presumably not directly used in performance of the exercise) and in the muscles of the unexercised arm. In this experiment, an attempt was made to study the mechanism of these exercise effects by using tambours to record the presence of muscular contraction. From the data obtained it was concluded that contraction of one muscle in the arm resulted in a diffusion of motor impulses which produced contractions in the associated accessory muscles, and this, presumably, accounted for the improvement of muscular performance. Since the exercise effects also appeared in muscles of the unexercised arm, it was inferred that the diffusion of motor impulses spread from the exercised to the unexercised arm. In accounting for the exercise effects in the unexercised member the authors concluded: "... it must not be claimed that muscles do not receive cross-exercise until more refined methods of observation are used than heretofore available in such experiments"[1] (7, p. 37).

A series of recent investigations by Davis (1–3) have given considerable support to the theory that the transfer effects of systematic exercise are due to "cross-exercise." These studies indicate that simple voluntary movement in one limb is accompanied by muscular activity in all four limbs, i.e., in an extension of the right foot, with subject reclining, there is not

* The writer is indebted to Mr. Robert L. Stumpner, who assisted in testing and training many of the subjects.

[1] C. Wissler and W. W. Richardson, "Diffusion of the Motor Impulse," *Psychological Review*, **7**: 37, 1900.

only the normal muscle activity in the extensor muscles of that member, but there is also muscle activity in the extensor muscles of the left foot and the two hands. While this remote activity is much less than that of the active member, it is, nevertheless, substantial. In view of the general results obtained in transfer studies, it would seem that this remote activity is great enough to constitute a form of muscular exercise.

One of the most recent and comprehensive studies on the transfer effects of exercise appears to be that of Hillebrandt, Parrish, and Houtz (5). This study involved training with heavy weights, a modified Mosso finger ergograph, and a grip dynamometer. The results obtained were in general agreement with previous reports. From observations of their subjects in action, the experimenters concluded that the transfer effects of exercise were probably due to the diffusion of motor impulses and to tonic postural reflexes.

While the cumulative weight of evidence leaves little doubt but that the transfer effects are genuine, there appear to be a number of disturbing features relative to the experimental procedures of most, if not all, of the reported studies. Among the most common criticisms which can be made are the following:

1. In some instances, conclusions are based on evidence obtained from only one or two subjects.
2. The subjects and authors often appear to be the same persons.
3. From a description of the training procedures used, it would seem that the so-called unexercised members were often actively engaged in supporting the other functions.
4. None of the experiments have used control subjects, and it is impossible to estimate how much of the transfer effect was due to the experimental variable and how much to factors external to the experiment.

In view of these shortcomings, it was deemed worthwhile to further explore the transfer effects of systematic exercise. The experiment herein reported presents data relative to the bilateral effects of a systematic exercise program involving simple flexion and extension of the right forearm. While the general procedures make no claim for originality, the experiment was conducted under the following conditions:

1. No subject had any insight into the hypothesis being tested; consequently, the data obtained were probably not influenced by any psychological factors arising out of preconceptions of what the results should be.
2. During exercise the body was always placed in such a position that the unexercised member was not called upon to give support, maintain stability, etc.
3. A control group was utilized as a means of estimating the changes observed in the experimental group.

## Apparatus and Procedures

The general arrangement of the apparatus and the disposition of the subject is shown in Figure 1. As can be seen from this photograph, the apparatus consisted of three exercise stalls set up along a long, sturdy table. A padded arm rest was mounted in each stall. This served to fix the upper arm and enabled an isolated muscle group (flexors of the forearm) to work against resistance until exhaustion. A length of leaded iron pipe, 1½ inches in diameter, and weighting 14 pounds, served as the resistance.

A 2 inch x 1½ inch wooden bar was mounted across each stall. The adjustment between the bar and the arm rest was such that when the subject flexed his forearm to 90 degrees his hand came in contact with the bar. The outer surface of the bar (surface nearest subject) was well padded with foam rubber and served as a head rest. A padded metal plate was mounted on the inner surface of the bar. Contact of the plate with the hand closed a micro-switch and activated an electric counter, which automatically counted the arm flexions.

FIG. 1. Arrangement of apparatus and disposition of subjects

A metronome, wired into a buzzer circuit, served to set the rate at which arm flexion and extension was made. The metronome was adjusted to sound the buzzer at the rate of 70 per minute. This rate gave a total of 35 arm flexions per minute.

Standardized instructions were read to the subjects throughout the initial trials. During this reading the experimenter sat at one of the exercise stalls and gave a demonstration of postural adjustment, type of movement desired, etc. The text of the instructions, which explains the

subject's postural adjustments, general testing procedures, etc., was as follows:

> This is a test of muscular endurance. Your task will be to flex and extend your arm while holding this weight in the palm of your hand. Your flexion and extension will be done to the rhythmical sounding of a buzzer.
>
> At the start of the test, you will seat yourself in the chair before the exercise table as I am now seated. You will place your arm in the padded arm rest, and you will grasp the weight with the arm extended and the palm up. The side of your chest rests against the front of the padded arm rest. Your forehead rests against the padded cross bar, and your feet will be placed flat on the floor in front of the chair. Your other arm will rest comfortably on the table with the palm up. At no time should you attempt to use this arm during the test.
>
> You will note that when you flex your arm to right angles, your hand will come in contact with the padding across the inner surface of the cross bar. Coming in contact with the bar activates a counter and automatically counts your arm movements. It is not necessary to bang the bar with any great force; a light contact is sufficient to activate the counter.
>
> When you have seated yourself and made the correct adjustments, I will start the buzzer. After you have had several minutes to learn the rhythm, I will give the signal and you will start flexing and extending your arm as long as you can.
>
> When you reach the point where you fail to keep up with the rhythm for two consecutive movements, you have reached the limits of your performance for the purpose of this test. At this point, you will place your hand on the table and sit quietly until I tell you to stand up. When all subjects have gone their limit, I will give the signal for you to leave the table.
>
> REMEMBER THIS IS A TEST OF MUSCULAR ENDURANCE! The success of this test depends upon your cooperation. Do you have any questions?

Upon completion of this explanation and demonstration, the subjects were seated in the chairs before the exercise stalls. After checking for and correcting any postural faults, the buzzer was sounded to demonstrate the nature and the rhythm of the stimulus to which they would react.

It is to be noted that at no time during the experiment were the subjects introduced to the precise nature of the hypothesis under investigation; as indicated in the instructions, the experiment was presented simply as a series of muscular endurance tests.

A group of undergraduate university men were given an initial test on left arm performance. On the basis of this test, it was possible to select ten pairs of subjects with approximately equal scores. In forming the experimental and control groups, one man of each matched pair was assigned to each group by the toss of a coin. The general experimental procedures were as follows:

1. Both groups were given an initial test on left arm performance.
2. Following the initial test, the experimental group received three weeks of systematic exercise in flexion and extension of the right arm. During this training period, the subjects took what they considered to be a good workout at their own rhythm on Monday, Wednesday, and Friday. On Tuesday and Thursday the subjects went all out under regular testing conditions.

3. At the end of the training period, both groups were retested on their left arm performance.
4. Two weeks after the training period, both groups were again tested on their left arm performance.

RESULTS

Table 1 presents the experimental data on the bilateral effects of muscular exercise. A comparison of the means and standard deviations of the

TABLE 1

*Data on bilateral effects of exercise*

| GROUP | PRE-EXERCISE LEFT ARM | | END EXERCISE LEFT ARM | | POST-EXERCISE LEFT ARM | |
|---|---|---|---|---|---|---|
| | Mean | $\sigma$ M | Mean | $\sigma$ M | Mean | $\sigma$ M |
| Experimental | 53.5 | 3.820 | 79.8 | 3.646 | 62.1 | 4.630 |
| Control | 53.2 | 3.946 | 58.2 | 5.896 | 58.4 | 5.033 |

TABLE 2

*Summarizing changes in left arm performance as a result of exercising right arm*

| GROUP | MEAN GAIN LEFT ARM AT END OF EXERCISE | MEAN GAIN LEFT ARM POST-EXERCISE |
|---|---|---|
| Experimental | 26.3 | 8.6 |
| Control | 5.0 | 5.2 |
| Difference | 21.3 | 3.4 |
| $\sigma$ Difference | 5.153 | 5.391 |
| t | 4.134 | 0.631 |
| df | 9 | 9 |
| P | below 0.01 | above 0.5 |

initial left arm performance (Pre-Exercise, Left Arm) reflects the extent to which it was possible to match individuals in each pair. Actually, the difference in initial left arm performance between the individuals in each pair was never greater than 5 per cent of the range of scores, and these were effectively balanced between the two groups.

Table 2 summarizes the mean gain at the end of the exercise period and the post-exercise period for both groups. The mean difference between groups was determined from the distribution of differences between pairs. At the end of the exercise period the experimental group showed a mean gain of 21.3 flexions over the control group. That this difference is significant is revealed by a $t$ value of 4.134. For 9 degrees of freedom, a $t$ value of 3.250 is significant at the 1 per cent level of confidence. Any hypothesis that this difference could be attributed to chance is thus rejected.

In the post-exercise tests the experimental group showed a mean gain of 3.4 flexions over the control group. This difference is not statistically

significant and could well be attributed to chance factors. It is, however, of significance to note the rapidity with which the experimental group loses its superiority during the post-exercise period.

## DISCUSSION

The evidence obtained shows that a systematic exercise program involving the flexion and extension of one arm results in a positive and significant improvement in the muscular performance of the other arm. While these results are in general agreement with earlier studies, they must be interpreted with some caution. It is, of course, possible that the bilateral effects were due simply to a raising of the subjects' tolerance to fatigue sensation. During strenuous and systematic exercise of one group of muscles a person probably learns to ignore or tolerate the feelings of muscular fatigue for a greater period of time, and this may transfer and influence the performance of other muscle groups. Also it is possible that the training effect is due to a bilateral transfer of motor coordination. On the other hand, the fact that bilateral gains are rapidly lost after the cessation of exercise suggests the gains are due primarily to exercise.

This suggestion is further supported by the Davis studies (1–3), which show that simple voluntary movement of one extremity results in muscular excitations in all four extremities. These facts of remote muscular excitation provide a possible mechanism through which the bilateral effects of muscle activity can occur. The results of the present study indicate that remote muscular excitation can be utilized to improve the muscular performance of remote musculatures.

The investigations by Davis, along with the several studies supporting one of the theoretical implications in Davis' findings, imply a conception of muscular activity quite unlike that of general kinesiology. As stated by Davis[2] (2):

> Even in a very simple sort of response there is a widespread "structural" pattern of action. The true unit of activity must be, not the flexing or extending of a particular muscle or limb, but an adjustmental design in which many regions of the organism participate.

It is suggested that further insight into the nature, extent, patterns, and conditions of remote muscular excitation will lead to a better understanding of physical education activities and corrective procedures. That the transfer effects of exercise may be used as a therapeutic tool has been suggested by Hillebrandt, Parrish, and Houtz (5).

## SUMMARY

Twenty male college students were employed in a study to test the bilateral effects of systematic exercise. Ten students received three weeks of exercise in flexion and extension of the right arm. Ten control students re-

[2] R. C. Davis, "The Pattern of Muscular Action in Simple Voluntary Movement," *Journal of Experimental Psychology*, **31**: 363, 1942.

ceived no special exercise. At the end of the exercise period, the experimental group showed a significant gain over the control group in flexion and extension of the left arm. Two weeks after the exercise period the experimental group lost their superiority over the control group in their left arm performance. It is suggested that exercise of one arm produces a positive and significant improvement in the muscular performance of the other arm.

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# A Frictional Bicycle Ergometer

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THE FRICTIONAL type of bicycle ergometer, in which resistance to pedaling is supplied by friction against the wheel of the bicycle, was the only type used in physiology until the second decade of this century. The ones of that day had various constructional and operational drawbacks, however, which made their use rather difficult. Therefore, two other types, the electrodynamic and the electromagnetic, were developed. In the electrodynamic type (5, 8), an electric dynamo geared to the bicycle supplies the needed resistance. In the electromagnetic type (3), the back wheel of the bicycle is replaced by a copper disk revolving between the poles of an electromagnet, which acts as a brake.

Unfortunately, these two types of ergometers are expensive, require expert installation, calibration, and handling.

In one investigation (4), the present writer decided to use nine bicycle ergometers. The cost of electrodynamic or electromagnetic bicycles would have been prohibitive; moreover the installation and calibration would have required expert attention. For this reason, it was decided to use the frictional type described by Martin in 1914 (7). Martin called it a "simple and convenient form", but in the writer's experience, it proved to be neither. The adjustment of the two spring scales on each bicycle required four hands and a "blitz" mental calculation, and the thin fabric from which the brake bands were made did not last long. Mechanical engineers were consulted about the frictional bicycle ergometer described by Lamb (6). In their opinion, it had constructional weaknesses because the flywheel had to be weighted with a lead piping around the rim, complicating the balancing of the wheel. A model described by Amar (1) was also judged to be impractical.

After trying out a number of variations in the construction of the ergometer, the present modification was designed. During the first experiment which lasted over four months and involved the use of the bicycles for several hours daily, the bicycles were kept in working order by a high-school student. These ergometers are now 10 years old. They have been ridden for over 4000 miles; moreover, they have been used by students in laboratory work where they are often abused. Yet they are still in working shape and, with the exception of replacing worn out pedals and other small parts, they have required little attention.

For schools of physical education, this improved frictional ergometer

may be of great practical importance. Most of these schools have very small budgets, if any, for laboratory work in physiology of exercise. Often, space is also limited. Yet, for efficient teaching, a laboratory may require several bicycle ergometers. They should be inexpensive, simple to construct, install, maintain, and operate. They also should be able to withstand hard usage by students, and preferably be portable.

The simplicity of operation of the frictional bicycle ergometer explains why it has been used by other investigators. For instance, Asmussen and Bøje (2) used this type although there was an electromagnetic one available.

During the past three years, the writer has received a sufficient number of inquiries regarding the frictional bicycle ergometer to warrant the writing of the present article.

*Construction of the Ergometer.* An ordinary bicycle can be easily converted into this ergometer, although the reconversion of a commercial stationary bicycle gives a more compact machine. The ergometer described here, and shown in Figure 1, represents such a reconverted "Rollfast" exercise bicycle. The original solid rubber tire on the front wheel has been replaced by a one and one-half inch wide, and three-quarters of an inch thick steel band welded to the rim and made true on a lathe. The total weight of the wheel is about 20 lbs.; thus this wheel has acquired also the function of a flywheel. Because of the momentum developed by this wheel, the operation of the bicycle becomes smooth. Without the flywheel, the movements of the legs would be jerky, and fatiguing, and the speed would fluctuate considerably. A length of automobile brake band (*D*) has been placed around the flywheel. The upper end of the brake band is connected with a spring scale (*A*) by means of a cord, and the lower end of the brake is connected with suspended weights (*B*) and (*C*). The cords are guided by the three ball-bearing pulleys (*F*). (The number of pulleys may be reduced to two.) The bicycle is bolted to the platform, to which is attached a frame (*G*) supporting the scale and the weights. The sizes of the platform and the frame are arbitrary. Rather convenient dimensions are: length of the platform, 5 feet; width of the platform and the frame, 20 inches; distance of the upper cross piece of the frame from the floor, 5 feet; distance of the lower cross piece from the floor, 3 feet. These dimensions are arbitrary. Anyone can re-design this construction to fit his own conditions.

When a need arose for an ergometer to be used in a low pressure chamber, the writer designed a very compact, portable ergometer that could fit the space available.

The bicycle has a speedometer (*E*) showing the speed in miles per hour and the distance covered by the flywheel. It can be reset to zero before a ride. (An old automobile speedometer of resetting type may be used.) If the radius of the flywheel differs from that of the ordinary bicycle for which the speedometer has been manufactured, a correction table can be made easily by measuring the distance traveled by any point on the flywheel corresponding to one mile on the speedometer. A tally counter, recording

either the number of wheel revolutions or pedal revolutions (or both) can be installed. The rate of pedal revolutions may also be conveniently controlled by a metronome.

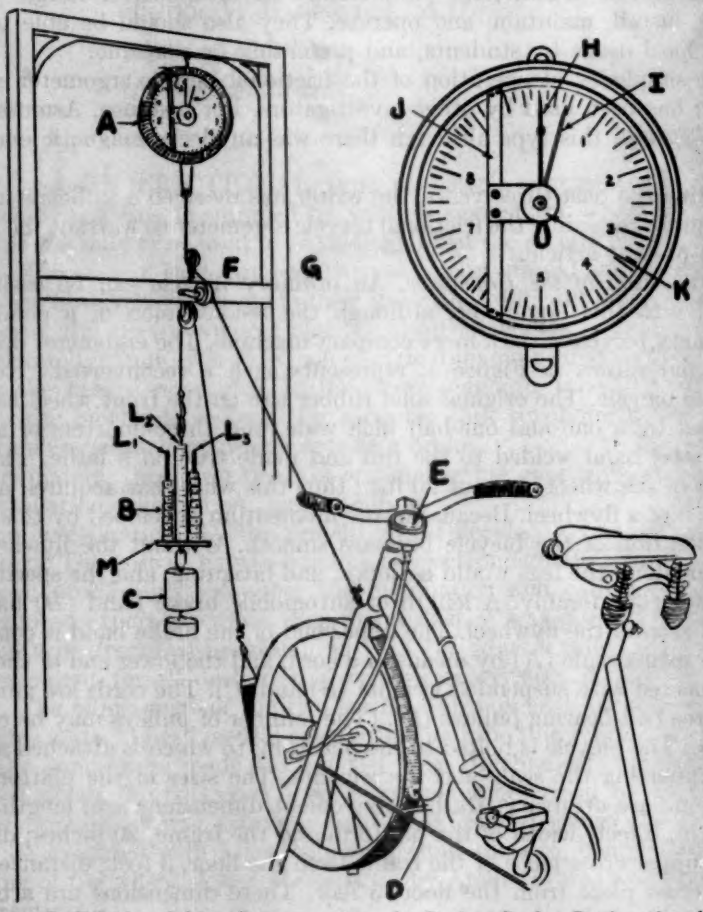


FIGURE I. Frictional bicycle ergometer. *A*—Spring Scale, *B*—fractional weight holder, *C*—weights, *D*—brake, *E*—speedometer, *F*—pulleys, *G*—frame, $L_1$, $L_2$, $L_3$ supporting rods, *M*—Crossbar holding vertical rods together.

*Inset.* Spring scale, *H*—Indicator, *I*—marker, *J*—bar, *K*—wheel for moving, *I*

*The Spring Scale.* (Figure 1 inset) The spring scale is an ordinary commercial scale graduated in one ounce divisions up to 10 lbs., but capable of withstanding a much larger load. This sturdy scale is preferred to a lighter one, say a two-pound scale described by Lamb (6), because it increases the ergometer's durability. Most of the weights used are heavier than five lbs. Occasionally a 20-pound weight may be used. When a bicycle is stopped

suddenly, a heavy weight may completely ruin a light spring scale. In order to note possible changes in the position of the pointer, a special marker (*I*) is attached to the scale. The marker can be set at any position by turning the wheel (*K*) supported by a bar (*J*).

*The Fractional Weight Holder.* (Figure 1) The holder consists of three rods, $L_1$, $L_2$, and $L_3$ held together by a horizontal bar. The purpose of the outer rods is to hold the one ounce fractional weights. To the middle rod is attached a rule divided into sections equal to the height of a single weight. Each section is numbered from one to 16 upward so that the number of weights can be told at a glance. The hexagonal nuts, made to weigh one ounce each by drilling a hole in the side, have been found to be expedient as fractional weights. The holder is suspended from the cord attached to the lower end of the brake belt. The middle rod has a loop from which the main weights are suspended. The spring scale is so adjusted that when the empty fractional weight holder is attached to it, the reading will be zero.

*Principle of Operation.* Work load in this type of ergometer is provided by the resistance caused by the friction between the flywheel and the brake band. The amount of friction is controlled by the weights, (*B*) and (*C*), shown in the illustration. When the bicycle chain is removed from the flywheel, the reading on the spring scale is equal to the suspended weight. When the subject pedals the bicycle, the friction of the wheel against the brake band lifts and partially supports the suspended weight. The reading on the scale therefore is reduced by an amount equal to this friction. Thus the friction or work load is equal to the weight suspended minus the scale reading.

Suppose it is desired to have five lbs. of work load. To obtain this, make (*C*) equal to four and one-half lbs. and place eight one-ounce weights on (*B*) so that the sum of (*C*) and (*B*) will equal five lbs. Let someone ride the bicycle and observe the reading on the scale. Suppose that the scale is eight ounces. This means that the friction is $\underset{\text{(weight)}}{5 \text{ lbs.}} - \underset{\text{(scale reading)}}{8 \text{ ounces}} = \underset{\text{(friction)}}{4 \text{ lbs. } 8}$ ounces. Since it was desired to have friction equal to five lbs., it is necessary to place on the weight holder eight ounces more and the friction then will become: $\underset{\text{(weight)}}{5 \text{ lbs. } 8 \text{ ounces}} - \underset{\text{(scale reading)}}{8 \text{ ounces}} = \underset{\text{(friction)}}{5 \text{ lbs.}}$, The marker (*I*) should then be moved so that it will be over the pointer (*H*) and the experiment may be started.

Suppose that during the experiment, the pointer (*H*) on the spring scale moves three one-ounce divisions clockwise. Thus, the scale reading becomes three ounces greater, which means that the friction for some reason has decreased by three ounces. To bring the friction back to the original value, three ounces must be added to the fractional weight holder and the marker (*I*) reset over the new position of the pointer (*H*). If the pointer moves counterclockwise and the scale reading becomes less than before, it means that the friction has increased by the corresponding number of

ounces. To bring back to the original, an equal weight must be removed from the fractional weight holder and the marker reset.

A simple rule may help in making adjustments: *If the pointer moves DOWN, put DOWN additional weight. If the pointer moves UP, lift UP weight from the fractional weight holder.* By keeping the flywheel well polished and the brake band clean, "spontaneous" fluctuations in scale readings may be entirely eliminated. In passing, it should be stated that under usual laboratory conditions friction is not affected by the speed of the flywheel.

*Sweat Guard.* During prolonged experiments riders may sweat profusely. Drops of sweat falling on the flywheel will play havoc with friction. To prevent this, it is strongly recommended that a sweat guard be placed above the flywheel. Transparent plastic material will be found convenient for this purpose, because it does not hinder observing the brake band and the flywheel.

*Calculations of Work Done on the Bicycle Ergometer.* The general formula for work is F × D, where F is force used and D, the distance covered. In the case of the bicycle, the force obviously is equal to the resistance to be overcome; therefore, F is equal to the weight suspended minus the scale reading. The distance D is equal to the distance traveled by the flywheel. This can be found if the circumference of the flywheel, $2\pi r$ is multiplied by the number of its revolutions during a given period, n, or $2\pi r \times n$. Work done on the ergometer in a given time, therefore, is equal to $F \cdot 2\pi r \cdot n$ or (friction) × (wheel circumference) × (number of wheel revolutions during that time).

Sometimes exercise on the bicycle is designed so that the rider has to perform a specified number of pedal revolutions per minute. Suppose that the amount of work desired is 4,350 ft.-lbs. per minute, and the number of pedal revolutions is to be 60 per minute. To calculate the required friction, it is necessary to find out the number of feet traveled by the flywheel for each pedal revolution. Suppose that one pedal revolution corresponds to 14.5 feet of distance covered by the flywheel. Then the distance covered in 60 pedal revolutions per minute will be 14.5 ft. × 60 = 870 ft. Since the total amount of work desired per minute is 4,350 ft. lbs., the friction must be 4,350 ft. lbs ÷ 870 = 5 lbs.

*Suggestions for Type and Number of Weights.* It has been found expedient to have the following weights for each bicycle: one each of one-half, one, two, four, and ten lbs. These weights may be cast of lead, and should have a hook on the top and an eyelet at the bottom. They should be plainly marked as to their weights. In addition, 32 one-ounce weights are required for the fine adjustments.

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# A Questionnaire Study Concerning the Development of Co-Education in College Physical Education

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WITHIN the past two decades a host of factors have given impetus to the development of co-education in college physical education. Studies made by Dalrymple,[1] Cobb,[2] and Bookwalter[3] have pointed out the significant progress which was made in this area during the 1930's. The entry of this country into World War II served as a temporary check to these developments. The paucity of civilian male students upon college campuses during the war years, along with the great emphasis placed upon physical development in college programs, combined to halt temporarily further developments in co-education. With the return of peace in 1945, it seemed quite natural to expect a resumption of these developments which had begun during the decade preceding the war.

The present study which was made in the spring of 1947 sought to determine: 1) present practices in co-education in college physical education, 2) opinions of persons prominent in college physical education concerning co-educational developments.

The gathering of this data was made possible only through the cooperation of the men and women college physical educators who participated in the questionnaire study. Appreciation is here expressed to these people and to Miss Helen Hazelton, Purdue University, and Dr. Harry Scott, Teachers College, Columbia University, for their assistance in selecting the participants for the study and their advice in respect to the content of the questionnaire.

## Method

The questionnaire method was employed to secure the data for this study. A group of 118 men and women engaged in college physical edu-

[1] Gerald R. Dalrymple, *A Survey of Co-Educational Physical Education in Leading American Universities and Colleges.* M.S. Thesis (Unpublished), Louisiana State University, 1937.

[2] Louise S. Cobb, "The Co-educational Physical Education Class at the College Level," *Research Quarterly*, **10:** 20–32, December, 1939.

[3] Karl W. Bookwalter, "The Co-educational and Co-recreational Use of Physical Education Activities," *Proceedings of College Physical Education Association*, p. 62–68, December, 1940.

cation were selected to participate in the study. In the selection of these men and women consideration was given to their present positions, their professional experience, and the geographical location of the colleges and universities at which they were serving. Since the questionnaire sought not only *opinions* but also factual information regarding the *present practices* in co-education in college physical education, a wide geographical representation was desired. Consideration was given to the geographical districts designated by the American Association for Health, Physical Education, and Recreation.

The selection of the women to whom questionnaires were sent was made with the assistance of Miss Helen Hazelton of Purdue University, formerly president of the National Association for Physical Education for College Women. A group of sixty-three women was selected to participate in the study. The selection of the men to whom questionnaires were sent was made with the assistance of Dr. Harry A. Scott of Teachers College, Columbia University, formerly president of the College Physical Education Association. A group of fifty-five men was selected. The study was endorsed by both the College Physical Education Association and the National Association of Physical Education for College Women.

TABLE 1

*An analysis of questionnaire distribution and return*

| DISTRICT | MEN | | | WOMEN | | | COMPOSITE | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sent | Returned | Per cent of return | Sent | Returned | Per cent of return | Sent | Returned | Per cent of return |
| Eastern | 14 | 13 | 92.85 | 13 | 12 | 91.54 | 27 | 25 | 92.59 |
| Midwest | 14 | 14 | 100. | 17 | 16 | 94.12 | 31 | 30 | 96.77 |
| Central | 8 | 7 | 87.50 | 10 | 8 | 80. | 18 | 15 | 83.33 |
| Southern | 8 | 7 | 87.50 | 9 | 9 | 100. | 17 | 16 | 94.12 |
| Northwest | 6 | 4 | 66.67 | 6 | 6 | 100. | 12 | 10 | 83.33 |
| Southwest | 5 | 5 | 100. | 8 | 7 | 87.50 | 13 | 12 | 91.54 |
| Totals | 55 | 50 | 90.90 | 63 | 58 | 92.06 | 118 | 108 | 91.52 |

Table 1 includes a compilation of the distribution and return of the questionnaires. The response was particularly gratifying. Of the 118 questionnaires distributed, 108 were returned—a percentage of 91.6. A total of seventy-nine colleges and universities were represented by the 108 returns. The percentage of return from questionnaires distributed to male physical educators was 90.0. Two of the men to whom questionnaires were sent referred them for reply to members of the women's physical education departments in their respective colleges. Apparently in these two institutions co-education in physical education is administered largely by the women's department. The percentage of return from questionnaires distributed to women physical educators was 92.1. The comparably high percentage of return from both men and women engaged in college physical

eduation would indicate considerable mutual concern with co-education, and should tend to dispel the belief that male physical educators are indifferent to developments in this area.

## Part I

### OPINIONS

*Providing for Co-Education.* Table 2 indicates the opinions of the prominent physical educators concerning the desirability of providing for co-education in some phase of the college physical education program. A five point rating scale ranging from definitely desirable to definitely undesirable was employed. An overwhelming majority of the group indicated that it is definitely desirable to provide for co-education in some phase of the program. Only slightly more than one per cent of the group were uncertain

TABLE 2

*Opinions concerning the desirability of providing for co-education in some phase of the college physical education program*

| RATING | MEN | | WOMEN | | COMPOSITE | |
|---|---|---|---|---|---|---|
| | No. | Per cent | No. | Per cent | No. | Per cent |
| Definitely desirable | 40 | 83.3 | 50 | 83.3 | 90 | 83.3 |
| Probably desirable | 5 | 10.4 | 10 | 16.7 | 15 | 13.9 |
| Uncertain | 1 | 2.1 | — | — | 1 | 0.9 |
| Probably undesirable | 1 | 2.1 | — | — | 1 | 0.9 |
| Definitely undesirable | 1 | 2.1 | — | — | 1 | 0.9 |
| Totals | 48 | | 60 | | 108 | |

or considered it undesirable to make provisions for mixed participation in physical education. There was no significant difference between the opinions of the men and women participating in the study.

*Phase of Program in Which Provision Should Be Made for Co-Education.* Table 3 indicates the opinions of the participants in the study concerning the phases of the physical education program in which provision should be made for co-education. Approximately 77 per cent of the group believed it very desirable to provide for co-education in the organized voluntary program (no credit given). Sixty of the group, or 55.6 per cent, of those responding indicated that it would be very desirable to include some provision for co-education as an elective within the prescribed program (credit given). A surprisingly large percentage, 21.3, believe that some co-education in physical education should be provided in the program required of all students. Only 4.7 per cent of the group considered it very undesirable to provide for co-education in this phase of the program. The findings make it clear that many of the group believe that provision should be made in several different phases of the physical education program for co-education.

*Forces Fostering Development.* In an attempt to find out the relative im-

portance of some of the forces which have stimulated and fostered the development of co-education in college physical education, the opinions of a number of men and women prominent in college physical education were sought. Table 4 contains the findings. The group was asked to rate each of the listed factors on a five-point scale ranging from very significant to very insignificant.

According to the ratings of the group it would appear that the most significant factor in fostering the development of co-education in college

TABLE 3

*Opinions concerning the desirability of co-education in the various phases of the college physical education program*

| PHASE OF PROGRAM | VERY DESIRABLE | | DESIRABLE | | ACCEPTABLE | | UNACCEPTABLE | | VERY UNACCEPTABLE | | NO OPINION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent |
| As a phase of the *organized* voluntary recreational program sponsored by the department of physical education. (Instruction given where desired; no credit given) | 83 | 76.9 | 16 | 14.8 | 5 | 4.7 | 1 | 0.9 | — | — | 3 | 2.8 |
| As a phase of the unorganized spontaneous recreational program (facilities made available by the physical education department but no organized program sponsored. (No credit given) | 77 | 71.3 | 12 | 11.1 | 7 | 6.5 | 3 | 2.8 | 2 | 1.9 | 7 | 6.5 |
| As an elective within the prescribed program. (Credit given) | 60 | 55.6 | 19 | 17.6 | 18 | 16.7 | 2 | 1.9 | 1 | 0.9 | 8 | 7.5 |
| As an integral part of the prescribed program. (Required of all. Credit given) | 23 | 21.3 | 17 | 15.7 | 23 | 21.3 | 22 | 20.4 | 5 | 4.7 | 18 | 16.7 |

physical education is the increased emphasis which has been placed in education upon preparation for the worthy use of leisure time. Also considered as very significant factors were student interest in co-education and the increased emphasis in college physical education programs upon recreational activities such as golf, tennis and bowling. Of the factors listed the group considered the increased social freedom of women as the least significant factor. It must be noted, however, that 28.7 per cent of the group considered this a very significant factor. Because of the comparatively high percentage of very significant ratings given to each of the factors listed in Table 2, it must be concluded that the group considered all of them as significant factors, some more than others—in fostering the development of co-education in college physical education.

*Forces Hindering Development.* Listed in Table 5 is a tabulation of the opinions of the college physical educators concerning the relative significance of the factors and forces which have hindered the development of co-education in college physical education. Again the group was asked to rate each of the listed factors on a five-point scale ranging from very signifi-

TABLE 4

*Ratings of various factors in respect to their significance in fostering the development of co-education in college physical education*

| FACTOR | VERY SIGNIFICANT | | SIGNIFICANT | | PROBABLY SIGNIFICANT | | INSIGNIFICANT | | VERY INSIGNIFICANT | | NO OPINION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent |
| The increased emphasis in education upon preparation for worthy use of leisure time | 68 | 51.1 | 28 | 25.9 | 8 | 7.4 | 1 | .9 | 1 | .9 | 4 | 3.7 |
| The increased emphasis in college physical education programs upon recreational activities of a dual or individual nature, such as golf, tennis, etc. | 61 | 56.5 | 32 | 29.6 | 13 | 12 | — | — | — | — | 2 | 1.9 |
| Student interest. The natural interest of college men and women in associating with one another in informal social activities | 60 | 55.5 | 30 | 27.7 | 11 | 10.2 | 4 | 3.7 | 1 | .9 | 2 | 1.9 |
| The increased emphasis in college curricula upon *functional* education. (The teaching of these skills which are actually utilized in living) | 56 | 51.9 | 27 | 25 | 12 | 11.1 | 7 | 6.5 | 1 | .9 | 5 | 4.6 |
| Increased emphasis in physical education upon social as well as physical development | 54 | 50 | 40 | 37 | 7 | 6.5 | 5 | 4.6 | — | — | 2 | 1.9 |
| The evolving position of women in society. (Increased participation of women in the social, economic and political spheres of our culture) | 31 | 28.7 | 39 | 36.1 | 17 | 15.7 | 13 | 12 | 3 | 2.7 | 5 | 4.6 |

cant to very insignificant. Of the fourteen factors listed, the group considered the limitations of facilities as the most significant factor impeding the development of co-education in the college physical education program. Given the second highest percentage of very significant ratings was the factor of opposition or indifference of male physical educators to this type of program. This is in confirmation of the knowledge that in the majority of institutions sponsoring co-education in physical education, the impetus

TABLE 5

*Ratings of various factors in respect to their significance in hindering the development of co-education in college physical education*

| FACTOR | VERY SIGNIFICANT | | SIGNIFICANT | | PROBABLY SIGNIFICANT | | INSIGNIFICANT | | VERY INSIGNIFICANT | | NO OPINION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent |
| Limitations of physical education facilities. (Separation of men's and women's facilities, etc.) | 44 | 40.7 | 31 | 28.7 | 21 | 19.4 | 8 | 7.4 | 3 | 2.8 | 1 | .9 |
| Opposition or indifference of male physical educators toward co-education | 34 | 31.5 | 31 | 28.7 | 31 | 28.7 | 7 | 6.5 | 3 | 1.9 | 3. | 2.8 |
| Tradition. (Established custom of separating men and women for physical education) | 34 | 31.5 | 28 | 25.9 | 26 | 24.1 | 12 | 11.1 | 7 | 6.5 | 1 | .9 |
| Difference in athletic abilities of men and women | 29 | 26.9 | 38 | 35.2 | 21 | 19.4 | 13 | 10.2 | 4 | 2.7 | 3 | 2.8 |
| Lack of preparation of staff members for handling co-educational classes | 27 | 25 | 34 | 31.5 | 25 | 23.1 | 15 | 13.9 | 4 | 3.7 | 3 | 2.8 |
| Differences in strength and endurance of men and women | 25 | 23.1 | 40 | 37.9 | 23 | 21.3 | 15 | 13.9 | 5 | 4.6 | — | — |
| Administrative problems such as separation of men's and women's departments of physical education | 23 | 21.3 | 29 | 26.9 | 29 | 26.9 | 18 | 16.6 | 4 | 3.7 | 5 | 4.7 |
| Lack of interest of men students in such a program | 6 | 5.6 | 19 | 17.6 | 45 | 41.7 | 23 | 21.3 | 11 | 10.2 | 4 | 3.7 |
| Opposition or indifference of female physical educators toward co-education | 5 | 4.6 | 19 | 17.6 | 34 | 31.5 | 29 | 26.9 | 14 | 12.9 | 7 | 6.5 |
| The effect of World Wars I and II on Physical Education Programs. (Emphasis on physical development) | 5 | 4.6 | 11 | 10.2 | 16 | 14.8 | 38 | 35.2 | 30 | 27.8 | 8 | 7.4 |
| Sociological Considerations. Opposition of our form of society. (The mores of our culture frown upon men and women participating jointly in sports activities) | 3 | 2.8 | 14 | 12.9 | 19 | 17.6 | 41 | 37.9 | 27 | 25 | 4 | 3.7 |
| Opposition ofcollege presidents toward this program | 2 | 1.9 | 9 | 8.3 | 14 | 12.9 | 20 | 37 | 18 | 15.6 | 25 | 23.1 |
| Lack of interest of women students in such a program | 1 | 0.9 | 12 | 11.1 | 20 | 18.5 | 44 | 40.7 | 26 | 24.1 | 3 | 4.7 |
| Moral implications. (Fear of indiscreet relations resulting from such a program) | — | — | 4 | 3.7 | 14 | 12.9 | 43 | 39.4 | 39 | 36.1 | 9 | 7.4 |

for this development has come from the faculty of the women's physical education staff or the members of the Women's Athletic Association. It must be pointed out, however, that the large percentage of return of this questionnaire form from both male and female physical educators would suggest that among prominent men and women physical educators there is a comparably high interest in developments in this area.

Other factors which received a high percentage of very significant ratings were tradition, differences in athletic ability between men and women, and the lack of preparation of staff members for handling co-educational classes. The latter would suggest the need for placing increased emphasis in our professional preparation programs for physical education teachers upon the methods of handling co-educational classes. Those factors which the group felt were of comparatively little significance in hindering development in this area were moral implications or fear of indiscreet relationships developing between men and women, lack of interest of women students, and the opposition of college presidents. It is interesting that the lack of interest of men students in this type program was rated as a very significant factor by a higher percentage of the group than was the lack of interest of women students. In both instances, however, the percentage of very significant ratings was small, so small, in fact, as to suggest that the lack of student interest can not be considered a significant factor impeding the development of co-education in physical education.

*Probable Future Developments.* The present study, as well as previous studies made by Bales[4] and Bookwalter,[5] indicates that physical educators are of the opinion that co-education is not a fad or temporary development in physical education. An overwhelming majority of the participants in the study (88.9%) believe co-education will in the future increase in significance in physical education programs. Developments and trends in social and educational areas as previously suggested indicate that there is at present a preponderance of forces favorable to the further development of co-education in physical education.

*The Scope of Activities.* The scope of activities suitable for co-education is surprisingly large. Bookwalter[6] suggests that there are more than ninety-five different physical recreational activities suitable for boys and girls to participate in jointly. In making such a statement, he undoubtedly includes many social recreational activities such as checkers, chess, and shuffleboard, which are not normally included in the prescribed program of physical education.

The participants of the questionnaire study were asked to indicate the suitability of nineteen different sport activities for co-education. Each

[4] Mary Bush Bales. *Utilizing College Co-recreation as a Factor in Social Interaction.* M.S. Thesis (Unpublished), Louisiana State University, 1941.

[5] Karl W. Bookwalter. "The Co-educational and Co-recreational Use of Physical Education Activities." *Proceedings of College Physical Education Association,* pp. 62–68, December, 1940.

[6] *Bookwalter.* Op. cit., p. 62–68.

sport was rated in respect to a five-point scale ranging from very suitable to very unsuitable. The activities which received the highest percentage of very suitable ratings were social dancing, folk dancing, archery, horseback riding, hiking and ice skating. The activities which received the highest percentage of unsuitable and very unsuitable ratings were handball, softball, and fencing. (See Table 6.)

There was disagreement regarding the suitability of softball for co-educational situations. Several inserted comments on the questionnaire to the effect that softball would be suitable in certain informal situations such as a picnic or an outing, but not in highly organized and competitive situa-

TABLE 6

*Ratings of activities in respect to suitability for co-education*

| ACTIVITY | VERY SUITABLE | | SUITABLE | | PROBABLY SUITABLE | | UNSUITABLE | | VERY UNSUITABLE | | NO REPLY | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent | No. | Per cent |
| Social Dancing | 105 | 97.2 | 2 | 1.9 | — | — | — | — | 1 | 0.9 | — | — |
| Folk Dancing | 98 | 90.7 | 7 | 6.5 | 1 | 0.9 | 1 | 0.9 | 1 | 0.9 | 0 | — |
| Archery | 92 | 85.1 | 12 | 11.1 | 3 | 2.8 | — | — | — | — | 1 | 0.9 |
| Horseback Riding | 88 | 81.5 | 14 | 13. | 2 | 1.9 | 1 | 0.9 | 1 | 0.9 | 2 | 1.9 |
| Hiking | 86 | 79.6 | 17 | 15.7 | 1 | 0.9 | 1 | 0.9 | 0 | — | 3 | 2.8 |
| Ice Skating | 86 | 79.6 | 16 | 14.8 | 1 | 0.9 | 2 | 1.9 | 1 | 0.9 | 2 | 1.9 |
| Roller Skating | 79 | 73.1 | 19 | 17.6 | 2 | 1.9 | 2 | 1.9 | 1 | 0.9 | 5 | 4.7 |
| Golf | 78 | 72.2 | 26 | 24.1 | 3 | 2.8 | 0 | — | — | — | 1 | 0.9 |
| Bowling | 76 | 70. | 25 | 23.1 | 4 | 3.7 | 2 | 1.9 | — | — | 1 | 0.9 |
| Swimming | 72 | 66.7 | 24 | 22.2 | 4 | 3.7 | 3 | 2.8 | 2 | 1.9 | 3 | 2.8 |
| Badminton | 71 | 65.7 | 27 | 25 | 6 | 5.6 | 2 | 1.9 | — | — | 2 | 1.9 |
| Skiing | 67 | 62. | 28 | 25.9 | 6 | 5.6 | 2 | 1.9 | 1 | 0.9 | 4 | 3.7 |
| Table Tennis | 65 | 59.3 | 37 | 34.3 | 2 | 1.9 | 1 | 0.9 | — | — | 4 | 3.7 |
| Tennis | 50 | 46.3 | 44 | 40.7 | 7 | 6.5 | 4 | 3.7 | — | — | 3 | 2.8 |
| Fly Casting | 50 | 46.3 | 30 | 27.8 | 19 | 17.6 | 1 | 0.9 | 1 | 0.9 | 7 | 6.5 |
| Volley Ball | 16 | 14.8 | 39 | 36.1 | 36 | 33.3 | 13 | 12.9 | 1 | 0.9 | 3 | 2.8 |
| Fencing | 13 | 12 | 22 | 20.4 | 32 | 29.6 | 28 | 25.9 | 9 | 8.3 | 4 | 3.7 |
| Softball | 3 | 2.8 | 20 | 18.5 | 27 | 25 | 44 | 40.7 | 13 | 12. | 1 | 0.9 |
| Handball | 1 | 0.9 | 1 | 0.9 | 10 | 9.2 | 50 | 46.3 | 34 | 31.5 | 12 | 11.1 |

tions. A similar opinion was expressed in an article by Wohlford.[7] There seemed to be general agreement concerning the unsuitability of handball as a co-educational activity. Approximately 78 per cent of the participants rated this activity very unsuitable or unsuitable. With the exception of handball, softball, fencing, and volleyball, all activities included in Table 6 received a high percentage of suitable and very suitable ratings.

It may appear surprising to some that the activities fencing and modern dance are included in this list. Only 32 per cent of the physical educators participating in the study rated fencing a suitable co-education activity. Co-educational modern dance was not considered sufficiently popular to merit inclusion in the original list of activities which the physical educators

[7] Mildred Wohlford. "Co-recreational Softball." *Journal of Health and Physical Education*, **15**: 337, 1944.

evaluated. Perhaps both of these activities have been under-rated in respect to their suitability for co-education. Physical educators who have had experience with co-educational groups in either fencing or modern dance are enthusiastic concerning the suitability of these activities.

In addition to the list of activities included in the questionnaire the following were suggested by the participants as suitable for co-education: sailing, canoeing, riflery, tumbling, camping, field hockey, horseshoes, modern dance, croquet, cycling, and camping.

*Selection of Instructors.* It is generally agreed among college physical educators that either a man or woman instructor can satisfactorily handle a co-educational class provided he has the proper professional and personal qualifications.[8] Those who oppose either a male or female instructor alone handling such a class give reasons such as the following: (a) students of opposite sex do not respect the instructor; (b) unwholesome physical contacts are necessary; (c) the mental attitude of the class may hinder learning; (d) the instructor's knowledge of the opposite sex may be limited, and (e) the instructor may lack preparation to handle such a group. Apparently many believe that a properly qualified instructor of either sex can rise above these objections. This was the opinion of 76.4 per cent of the participants in the questionnaire study.

## Part II

### PRESENT PRACTICES

*Present Provision for Co-Education in the Program.* In contrast to the opinions of the participants concerning provision for co-education in physical education, it is interesting to note some of the present practices in this area. The study revealed that at 93.7 per cent of the colleges represented, provision is currently made in some phase of the physical education program for co-education. In 73.4 per cent of the schools, provision for co-education is made in the voluntary recreation program; however, at 46.8 per cent of the schools co-education is available as an elective within the required physical education program. In the original questionnaire an attempt was made to determine also whether any colleges required all students in the prescribed physical education program to participate in some co-educational activity. In responding to this question many apparently made no distinction between the required program for the general college student and the prescribed program for the professional student in physical education. Because of this, these findings will not be included. In her study in 1939 Cobb[9] found that no college which was surveyed required students in the prescribed program to participate in some co-educational activity. It is uncertain whether the situation in 1949 is the same. It is known, however, as indicated in Table 3, that a total of 23 college physical educators

[8] Mable Lee. *The Conduct of Physical Education*. New York: A. S. Barnes & Company, 1937.

[9] Louise S. Cobb. "The Co-educational Physical Education Class at the College Level," *Research Quarterly*, **10:** 30–32, December, 1939.

believe it very desirable to require some co-educational physical education of the students in the prescribed program.

*Unique Developments.* The questionnaire study revealed that in fifty of the seventy-nine colleges represented in the study co-educational clubs have been organized in various sport activities. At one university co-educational sports clubs in 12 different sports activities have been formed. Several colleges have as many as 9 co-educational sports clubs. The most popular activities for club organization are skiing, square dancing, badminton, swimming, hiking, modern dancing and fencing. The popularity of hiking and badminton clubs is rather commonly known. Daniels[10] in 1940 reported the existence of upwards of 75 collegiate hiking clubs. The current study revealed that hiking and badminton clubs exist in 25 per cent of the colleges surveyed. Sixty-five of the colleges indicated that they are providing for special co-educational sports events such as "Sports Nites," "Play Days," "Folk Dance Frolics," and "Mixed Swims."

Although not shown in the questionnaire study, it was revealed in a series of interviews that co-education is now finding expression in the voluntary recreation programs of many colleges whose student body is restricted to one sex. For example, West Point now encourages co-recreational sports activities on weekends. Such equipment as golf clubs, tennis racquets, and skiis are made available on weekends for the use of the cadets and their guests. Horseback riding and swimming are also popular. At Connecticut Wesleyan the Student Christian Association has made provision to have girls from such schools as Wellesley, Smith, Vassar, and Connecticut College visit the campus on weekends. On several of these occasions the department of physical education has organized co-educational swimming and hiking parties. Smith College students enjoy hiking and skiiing parties with students from Amherst. Women of Mount Holyoke College have participated with Amherst men in golf and riflery. Members of the outing club of Skidmore College have arranged various outing events with students from Union, Dartmouth, and Rensselaer. Although the departments of physical education in these schools are encouraging these activities, the students are initiating, planning and organizing the programs.

*The Segregation of Gymnasium, Swimming Pool and Tennis Court Facilities for Men and Women.* As evidenced by the study made in 1937 by Dalrymple[11] and the questionnaire study reported herein, the majority of colleges and universities in this country provide separate gymnasia for men and women. Dalrymple in his survey found that thirty-four of fifty-two, or 65.4 per cent of the schools studied, provided segregated gymnasium facilities. In the present study, it was found that fifty-two of seventy-nine

[10] Arthur S. Daniels. "College and University Outing Clubs," *Journal of Health and Physical Education*, 9: 278–81, May, 1938.

[11] Gerald Richard Dalrymple. *A Survey of Co-Educational Physical Education in Leading American Universities and Colleges.* M.S. Thesis (Unpublished) Louisiana State University, 1937.

or 64.6 per cent of the schools surveyed, provided separate gymnasium facilities. It was revealed also that swimming pools and tennis courts are more commonly shared by college men and women than are gymnasium facilities. At forty of the schools (50.6 per cent) the swimming pool is used by both men and women; and at sixty-four (81 per cent) the tennis courts are shared.

In the questionnaire study those physical educators whose schools maintained separate gymnasia were asked whether provision was made in the men's or women's gymnasium for dressing and shower facilities for the opposite sex. Of fifty-one schools maintaining separate facilities, twenty-eight or 54.9 per cent answered in the affirmative. Many of this group inserted comments to the effect that the provisions made in this respect were at best makeshift and inadequate.

## SUMMARY OF FINDINGS

1. The most significant factors fostering the development of co-education in physical education are: 1) the increased emphasis in education upon preparation for worthy use of leisure time, 2) the increased emphasis in physical education programs upon recreational activities, 3) the natural interest of college men and women in associating with one another in social activities, and 4) the increased emphasis in physical education upon social development.

2. The most significant factors hindering development in this area are: 1) the limitations of present facilities, 2) the indifference of male physical educators, 3) the tradition of separating men and women for physical education, 4) the difference in athletic ability of men and women, 5) the lack of preparation of staff members to handle co-education classes, and 6) the differences in strength and endurance of men and women.

3. It is definitely desirable to provide for co-education in some phase of the college physical education program.

4. Co-education is desirable in both the voluntary and prescribed phases of the program. It was the opinion of the questionnaire participants that the voluntary, non-credit phase of the program is the most desirable place for co-educational activities.

5. Either a male or female instructor may handle a co-educational class, providing he is professionally qualified, socially well adjusted, and in sympathy with this type of program. Obviously, a person who is openly skeptical of the merits of co-education would be unsuitable as an instructor for such a class.

6. There is a wide range of sport activities which are suitable for co-educational participation. Geographical location and facility limitations serve to preclude many of these activities from the program at a particular school.

7. Co-education in college physical education is not a fad nor has it reached its maximum development, but it will continue to increase in significance in our programs.

8. At seventy-four (94%) of the seventy-nine colleges studied, provision is currently made in some phase of the program for co-education.

9. At fifty-eight (73%) of these schools, opportunity for co-education is provided in the organized voluntary program, no credit given.

10. At thirty-seven (47%) of these schools students may elect co-educational classes within the prescribed program, credit given.

11. In fifty (63%) of the seventy-nine colleges studied, co-educational clubs have been organized in various sports. At one particular school co-educational sports clubs in twelve different sports have been formed.

12. At sixty-five (83%) of these schools provision is made for special co-educational events, such as Sport Nites, Folk Dance Frolics, Mixed Swims, Roller Skating Parties, and Play Days.

13. Co-education is finding expression in the weekend recreation programs of colleges whose student body is restricted to one sex.

14. At fifty-one (65%) of the colleges studied, separate gymnasia exist for men and women students. At 54 per cent of these schools provision is made in either the women's or men's gymnasium for dressing and shower facilities for the opposite sex.

*Implications of the Study.* The college physical education program can be enriched by providing opportunity in the prescribed and voluntary programs for co-education; there are manifold opportunities in both of these programs to develop co-education.

It would appear that if the development of co-education is to be fostered, curricula for the preparation of teachers of physical education must incorporate materials concerning the organization and operation of this type program. No new or distinct courses need be added to the present professional curricula to accomplish this. Existing courses in sport activities, principles, methods, and administration can satisfactorily encompass materials necessary to prepare the students for this aspect of the program.

It would also appear desirable for administrators of college programs to consider possibilities for the development of co-education when planning the construction or improvement of gymnasium and other physical education facilities. It has been pointed out in this study that the limitation of facilities is the most significant factor impeding the development of a co-educational program. Quite often educational philosophy and educational facilities have failed to develop together. Present college physical education programs are handicapped by the gap between accepted philosophy and existing facilities.

If, as suggested by this study, co-education in college physical education is desirable, administrators, along with their staffs, should proceed to foster, shape and direct this development by preparing personnel, providing facilities and leadership, and designing the program to include opportunities for wholesome, satisfying experiences in co-education.

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# A Study of the Physical Therapy Activities and Equipment in Veterans' Administration Hospitals

GILBERT R. SHUCK, M. P. E.

THE NEED for physical therapy treatment and activities has been greatly intensified since the end of the second World War by the return of disabled veterans to the universities and civilian life.

Because the need for such treatment is so great, much study has been done in this field. New activities and improved methods of treatment have been discovered, and as a result, the whole physical therapy program has been more effective.

This study is limited to seventeen of the more common ailments listed in the current files of Veterans' Administration Hospitals. The information has been carefully selected and compiled. The writer has made a thorough search for facts on the types of physical therapy equipment used for treating these various disabilities and also the activities assigned for each type of disability. It is hoped this study will assist the physical therapist who is administering treatments in the universities by helping him select the best activity or equipment for a specific ailment, so that, in turn, the student will be rehabilitated in less time and with less disabilities.

It is practically impossible to acknowledge the help of the many individuals in Veterans' Administration Hospitals who contributed to the compilation of these questionnaires and informational materials. Although the following acknowledgements, will, of necessity, be incomplete, appreciation is extended to the personnel of the following Veterans' Administration Hospitals: Muskogee, Oklahoma; Salt Lake City, Utah; Battle Creek, Michigan; Dallas, Texas; Indianapolis, Indiana; Columbia, South Carolina; Dwight, Illinois; Hines, Illinois; Jefferson Barracks, Missouri; Wichita, Kansas; Saratoga Springs, New York; and Lincoln, Nebraska.

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## Definition of Terms Used

*Arthritis*—a condition manifested ordinarily by inflammation of a joint.

*Dermatitis*—an inflammation of the derma, true skin.

*Diathermy*—machine used in physical therapy treatment which has a high frequency current. It may be used as a stimulative agent or as a sedative agent. Diathermy generates a continuous and steady heat within the affected parts, causing an increased blood supply to the deeper tissues.

*Faradic Current*—one of the oldest electrical currents. Its action is mechanical in effect. This current almost secures a normal motor nerve impulse, so it is used to re-educate nerve and muscle connection and for aiding circulation and nutrition which are poor.

*Functional Foot Defect*—a potential weak foot or disorder, which has not become fixed, for example, flexible flat foot.

*Galvanic Current*—a machine that causes a chemical action in the nerve endings, aids in relieving pain, stopping hemorrhage, and soothes inflammatory conditions.

*Heart Disease* (functional)—a functional disorder is a secondary condition derived from disturbances in the body mechanism, for example, murmurs.

*Heart Disease* (structural)—an organic heart disturbance characterized by a permanent malformation in some cardiac structure, for example, valves.

*Heat Cradle*—metal bridge-like equipment that can be placed on a bed for heating parts of the body. There are several light bulbs contained within the cradle.

*Hemiplegia*—a spastic paralysis (condition of hypertension in one set of muscles, which interferes with the normal action of the opposing or antagonistic muscles) involving one side of the body, for example, the right arm and right leg.

*Infra-red*—a lamp having a short wave that penetrates to the deeper tissues.

*Massage*—the scientific manipulation or handling of the soft tissues of the body for therapeutic purposes.

*Muscular Dystrophy*—refers to an atrophication of a muscle or muscles due to paralysis of the part involved.

*Neuritis*—an inflammation of a nerve.

*Osteomyelitis*—an inflammation of the bone.

*Physical Therapy*—includes the employment of the physical and other effective properties of ultra-violet and infra-red radiant energy, heat, cold, water, electricity, therapeutic exercise and massage in the treatment of disease and injury and for diagnostic tests.

*Poliomyelitis*—Infantile paralysis

*Sciatic Rheumatism*—a shifting inflammation or neuralgia, affecting the muscles, joints, or other structures in the sciatic region (pelvic and leg).

*Scoliosis*—a condition in which any series of vertebral spinous processes show a constant deviation from the median line of the body. The deviation may be right or left and functional or structural (curve of the spine).

*Sinus*—an opening in a bone generally adjacent to the respiratory tract and the seat of sinusitis.

*Sitz bath*—type of bath generally given for ailments of the pelvic region, for a person sits down in this properly shaped bath tub. It is con-

structed to fit the buttock. The water in the tub is warm enough to promote proper stimulation and relief.

*Spinal Fusion*—a condition as a result of fusing of the backbones (vertebrae).

*Ultra-violet*—a machine that produces rays for nourishing and stimulating tissues and relieving of pain. In stronger doses their rays act as bactericides.

*Vapor bath*—steam bath.

*Whirlpool*—a tank containing an agitator (propeller) and luke warm water. The object of this equipment is to stimulate circulation and to revitalize the part affected.

## The Study

The purpose of the following study is to determine the frequencies and effectiveness of activities and physical therapy equipment assigned to seventeen ailments by Veterans' Administration Hospitals as a basis for suggesting a possible physical therapy program at the universities. An attempt has been made to find the best kind of treatments and activities assigned to the following ailments: One Arm Missing; One Leg Missing; Poliomyelitis; Muscular Dystrophy; Hemiplegia; Heart Diseases (functional); Heart Diseases (structural); Foot Defects (functional); Neuritis; Sciatic Rheumatism; Arthritis; Scoliosis; Dermatitis; Spinal Fusion; Osteomyelitis; Sinus (colds, bronchitis, etc.); Kyphosis; and to rank in order, activities, physical therapy equipment, and the total number of cases of improvement.

To change and improve a physical therapy program, a knowledge of the facts of proper and up-to-date treatments and activities assigned to a particular disease or injury is necessary. The problems to be discussed under this heading will be limited to 1) the number of cases, 2) activities or sports assigned in order of frequency, 3) physical therapy assigned in order of frequency, 4) the number of cases having no, slight, good, or very good improvement, due to the prevailing treatments, 5) frequency of cases (pertaining to location), 6) frequency and order of importance of physical therapy equipment, and 7) total cases and frequency of the total number of cases of improvement.

The tables used in this research are summaries of the information obtained from the various hospitals on types of activities assigned and equipment used in the treatment of these disabilities. In each case an attempt has been made to show in Column 1 of the Table, the activities or sports used in the treatment of the disability for which the table is marked. The activities are ranked in the order of their importance. Since there is a difference in opinion as to the best type of therapy to be used in each case, the report of the findings from each hospital is listed. This is shown in Column 2 of the Table. Each number represents a hospital report. The number one indicates the most effective method used. The number two indicates the second most effective method used, etc. In Column 3 the

degree of improvement shown in the cases studied after the recommended therapy has been administered, is listed

*One Arm Missing*—Massage, whirlpool, in conjunction with exercise for strengthening the stump, are the most effective treatments used. The facts are that of the total of 7 cases reported, there are 3 of good improvement and 3 of very good improvement. It is possible that the findings would be slightly different if there were more cases available for study.

*One Leg Missing*—Observing the studies below, it is found that "leg" and "arm" amputees are similar in treatments. Massage, whirlpool, and possibly rhythmic constrictor are most frequently used for the best results.

TABLE 1
*One Arm Missing*

| ACTIVITY OR SPORT ASSIGNED IN ORDER OF EFFECTIVENESS | PHYSICAL THERAPY USED IN ORDER OF EFFECTIVENESS 1, 2, 3, | NUMBER OF CASES OF IMPROVEMENT |
|---|---|---|
| 1. Exercise for strengthening the stump<br>2. Occupational therapy | Diathermy ..... 1<br>Infra-red ..... 2<br>Massage ..... 2, 1, 1, 1<br>Whirlpool ..... 2, 1<br>Ultra-violet ..... 3<br>Exercise ..... 2 | No ..... 0<br>Slight ..... 1<br>Good ..... 3<br>Very good ..... 3<br><br>Total Cases ... 7 |

TABLE 2
*One Leg Missing*

| ACTIVITY OR SPORT ASSIGNED IN ORDER OF EFFECTIVENESS | PHYSICAL THERAPY USED IN ORDER OF EFFECTIVENESS 1, 2, 3, 4 | NUMBER OF CASES OF IMPROVEMENT |
|---|---|---|
| 1. Pre-prosthetic training<br>2. Prosthetic training<br>3. Hop Scotch<br>4. Golf | Diathermy ..... 3,3<br>Infra-red ..... 2, 2<br>Massage ..... 1, 1, 1, 1, 1, 1<br>Whirlpool ..... 2, 1, 2, 1<br>Ultra-violet ..... 4<br>Rhythmic Constrictor ..... 1, 2 | No ..... 2<br>Slight ..... 2<br>Good ..... 11<br>Very good .... 7<br><br>Total Cases .. 22 |

Pre-prosthetic and prosthetic training are the activities most frequently assigned. The results of the number of cases of improvement out of 22 are 11 good and 7 very good.

*Poliomyelitis*—Infra-red lamp therapy is used most frequently. However, massage and whirlpool are effectively used. Underwater exercise and re-education are subsequent assignments.

*Muscular Dystrophy*—It is difficult to determine which treatment is most effective in the case of muscular dystrophy. Massage, whirlpool, and activity exercises are used most frequently. Occupational therapy is the most frequent activity assigned. Any improvement would be slow and considered great encouragement. Out of five cases studied, three cases showed slight improvement; one case showed good improvement; and one case showed very good improvement. Because of the relative small number of cases studied, the results might not always be as reported.

*Hemiplegia*—Reports on hemiplegia indicate that infra-red and active and passive underwater exercises are the most frequently used. Bicycle (stationary) and exercise on stall bars are the activities assigned the most, respectively. The studies further indicate that treatments are progressing by having 50 per cent of the cases with "good or very good" improvement.

*Heart Diseases* (Functional)—Physical therapy equipment is not used generally for "Heart Diseases." Activities or sports are utilized according to the severeness of the heart ailment. Graded cardiac exercises are assigned to a person to the extent of his or her disability. Shuffleboard, golf, archery, fishing, and camping are among the sports assigned.

TABLE 3
*Poliomyelitis*

| ACTIVITY OR SPORT ASSIGNED IN ORDER OF EFFECTIVENESS | PHYSICAL THERAPY USED IN ORDER OF EFFECTIVENESS 1, 2, 3, | NUMBER OF CASES OF IMPROVEMENT |
|---|---|---|
| 1. Muscle retraining | Diathermy ..... 3, 2 | No ..... 1 |
| 2. Occupational therapy | Infra-red ..... 1, 1, 1, 1, 1 | Slight ..... 4 |
| 3. Walking in a walker | Massage ..... 2, 1, 1 | Good ..... 9 |
| 4. Swimming | Whirlpool ..... 2, 1, 1 | Very good .... 11 |
| | Ultra-violet ..... 2, 3 | |
| | Galvanic ..... 1 | |
| | Re-education ..... 1, 1, 1 | |
| | Hot packs ..... 1 | |
| | Underwater exercises ..... 2, 1 | Total Cases .. 25 |

TABLE 4
*Hemiplegia*

| ACTIVITY OR SPORT ASSIGNED IN ORDER OF EFFECTIVENESS | PHYSICAL THERAPY USED IN ORDER OF EFFECTIVENESS 1, 2, 3, 4 | NUMBER OF CASES OF IMPROVEMENT |
|---|---|---|
| 1. Exercise on stall bars | Diathermy ..... 1, 1 | No ..... 12 |
| 2. Bicycle (stationary) | Infra-red ..... 1, 1, 1, 1, 1 | Slight ..... 33 |
| 3. Occupational therapy | " ..... 1, 1, 2 | Good ..... 30 |
| 4. Correct walking | Massage ..... 1, 1, 1, 1, 2 | Very good ... 35 |
| 5. Pulley therapy | " ..... 2, 2, 3, 3 | |
| | Whirlpool ..... 1, 1, 3, 3, 4 | |
| | Active and Passive (underwater) exercise ..... 1, 1, 1, 1, 1, 1 | |
| | Re-education ..... 1, 2 | Total Cases .. 110 |

Functional heart disturbance does not indicate illness, but the person's "reserve strength" may not be sufficient to meet the demands of vigorous activity and sudden strain. Being a muscle, the heart needs exercise, as do other muscles of the body. By preventing over-fatigue, through the avoiding of excessive activity, mal-functional heart cases usually disappear. Out of forty cases, five showed no improvement and thirty-five showed only slight improvement.

*Heart Diseases* (Structural)—In an organic heart disturbance there is a permanent malformation in some part of the cardiac structure. When

the statement is made that organic conditions are permanent, it is meant that malformations of the structure of the valves or muscle cannot be cured, but the infection or toxin which has caused the condition may be eradicated. The scars in the valves or muscles prevent these tissues from becoming normal again.[1]

There are no structural heart disturbances as depicted by the surveys. However, some activities are cited. The general theme of thought is that of moderation of activities. This does not mean that an individual should lead a life of physical inactivity. The physician should estimate an individual's work capacity. Such sports as archery, camping, fishing, rope spinning, boating, shuffleboard, and croquet may be used for this type of ailment. The range of movement may be shortened in certain activities; continuity of action must be reduced to keep within the student's exercise tolerance; adequate rest period should be frequent; the student's natural skill must be taken into consideration.[2]

*Foot Defects* (Functional Foot—abducted foot, weak foot, flexible flat foot)—There seems to be more emphasis on activities rather than physical therapy for remedial treatment—that is logical since there has been a potential weakness in the plantar aspect of the foot. Heel cord stretching, picking up rocks, and sand walking are assigned, respectively in order of effectiveness. There is a choice of whirlpool and massage as far as physical therapy assignments. Due to the location and type of ailment, not too great an improvement is shown with the prevailing treatments. There are 45.1 per cent cases of slight improvement. Only four of the thirty-one cases studied showed very good improvement. Seven cases showed good improvement; fourteen cases showed slight improvement; and six cases showed no improvement.

*Neuritis*—There are a multitude of assignments for neuritis. Diathermy and infra-red lamp therapy are used most frequently. Activities that have been used are 1) rehabilitation exercises and 2) range of motion exercises. There is strong evidence that the present treatments are beneficial to the assignees by having 79.9 per cent cases show "good and very good' improvement.

*Sciatic Rheumatism*—It is understandable that diathermy and infra-red lamp therapy would be utilized the most, since they are deep penetrating, shortwave heating units. Sciatic rheumatism needs that type of treatment, since the sciatic nerve is well protected by external muscles and tissues. Exercises, depending on the degree of severeness, are prescribed as the best activities. Evidences show that there is 81.1 per cent of "good and very good" improvement, which is indicative of substantial assignments to the patients involved. Seventy-four of the 163 cases studied showed good improvement; 43 showed very good improvement. Only 17 did not respond to treatment.

[1] George T. Stafford. *Sports for the Handicapped*. New York: Prentice-Hall Inc., 1947, p. 159.
[2] *Ibid.*, p. 159.

*Arthritis*—There seem to be pronounced utilization of a variety of treatments, yet some assignments are outstanding. Infra-red seems to be the most utilized machine. Diathermy, massage, and whirlpool are mentioned in order of frequency, respectively. Activities of 1) exercise, depending on the severeness of the case; 2) exercise on the stall bars, and 3) shoulder wheel are reported being assigned in order of their frequency. There is no

TABLE 5
*Neuritis*

| ACTIVITY OR SPORT ASSIGNED IN ORDER OF EFFECTIVENESS | PHYSICAL THERAPY USED IN ORDER OF EFFECTIVENESS 1, 2, 3, 4, 5 | NUMBER OF CASES OF IMPROVEMENT |
|---|---|---|
| 1. Rehabilitation exercises | Diathermy.....1, 2, 1, 1, 1 | No..... 0 |
| 2. Range of motion exercises | Infra-red.....1, 2, 1, 1, 2 | Slight..... 38 |
| 3. Shoulder wheel | Massage.....3, 1, 3, 3 | Good..... 103 |
| | Whirlpool.....2, 1, 2 | Very good... 45 |
| | Ultra-violet.....2, 1 | |
| | Galvanic..... 4 | |
| | Cabinet bath.....5, 1 | |
| | Exercise.....4, 2 | Total Cases.. 186 |

TABLE 6
*Arthritis*

| ACTIVITY OR SPORT ASSIGNED IN ORDER OF EFFECTIVENESS | PHYSICAL THERAPY USED IN ORDER OF EFFECTIVENESS 1, 2, 3, 4, 5, 6, 7, 8 | NUMBER OF CASES OF IMPROVEMENT |
|---|---|---|
| 1. Exercises, depending on degree of severeness | Diathermy .....1, 4, 2, 2 | No..... 88 |
| 2. Exercise, stall bars | " .....1, 2, 1 | Slight..... 89 |
| 3. Shoulder wheel | Infra-red .....2, 1, 1, 1 | Good..... 349 |
| 4. Rowing machine | " .....1, 1, 1, 2 | Very good... 113 |
| | Massage .....1, 1, 1, 3 | |
| | " .....3, 3, 4, 5 | |
| | Whirlpool.....1, 2, 2, 2 | |
| | " .....4, 4, 6 | |
| | Ultra-violet.....1, 4, 7 | |
| | Cabinet bath.....2, 3 | |
| | Exercises (Passive).....1, 2, 2, 5 | |
| | Heat Cradle.....3, 8 | Total Cases... 639 |

doubt as to the effectiveness of the prevailing treatments—having 72.3 per cent of cases with "good and very good" improvement.

*Scoliosis* (Functional and Structural)—Most of the treatments given are pertaining to exercises—asymmetrical and postural. Lateral curvature is a progressive process of affection, halted by the resistance offered by the tissues, bones, ligaments, and muscles. If the affection is allowed, it becomes a fixed structural or organic form of curvature. The latter type of affection is very difficult to cure. Having a 62.5 per cent of "no" improvement indicates the difficulty of favorable prognosis. Ten of the sixteen cases studied showed no improvement and the other six cases showed only slight improvement. Again, if more cases were studied, findings might vary from the above report.

*Dermatitis*—Physical therapy seems to be the only prevailing assignment for treating skin disorders. Ultra-violet is definitely the most effective treatment. Forty-six of the 102 cases showed very good improvement and thirty-four others showed good improvement. Only five did not respond to treatment.

*Spinal Fusion*—Forced flexion exercises seem to be the only type of activity assigned. Massage and infra-red are the two assignments most frequently made. By utilizing these types of treatments, 50 per cent of the cases showed good and very good improvement. That percentage is excellent considering that a fixation may have resulted in some of the 32 cases. Six of the thirty-two cases did not respond to the treatment.

*Osteomyelitis*—It is rather common to perform surgical operations on such cases as osteomyelitis. The malignancy of the ailment determines the type of treatment it should receive. Most patients of osteomyelitis

TABLE 7

*Sinus (related illnesses)*

| ACTIVITY OR SPORT ASSIGNED IN ORDER OF EFFECTIVENESS | PHYSICAL THERAPY USED IN ORDER OF EFFECTIVENESS 1, 2, 3, 4 | | NUMBER OF CASES OF IMPROVEMENT | |
|---|---|---|---|---|
| None used | Diathermy | 1, 1, 1, 1, 1 | No | 7 |
| | Infra-red | 1, 1, 2, 3 | Slight | 2 |
| | Ultra-violet | 1, 1, 2, 3 | Good | 39 |
| | Massage | 2 | Very good | 67 |
| | Exercises | 4 | Total Cases | 115 |

improve slowly. If a case has not progressed too far, there are beneficial results deriving from physical therapy administration. Evidences are that 76.8 per cent had "slight and good" improvement. Whirlpool therapy is used most frequently. These findings are based on the thirteen cases studied.

*Sinus, Colds, Bronchitis, (etc.)*—Inspecting the accumulative data, physical therapy seems to be the main issue for treatment with diathermy having the most frequent assignments. Infra-red and ultra-violet are second in place as to use. The treatments used seem to be effective as 92.1 per cent of the cases show "good and very good" improvement.

*Kyphosis* (Round Shoulders)—Kyphosis, generally speaking, is a functional defect, however, it may become structural if proper treatment is not performed at the proper age. Physical therapy machines would not have very much effect upon this type of ailment. Activities and a few special sports obtain the optimum results. Corner exercises, lunge forward exercises, trunk rising against resistance, breast stroke in swimming, and volleyball are good assignments to aid in correction of round shoulders Such activities and sports have to be used during the growth and development stage of an individual to get the best results. No cases of kyphosis were being treated in the hospitals surveyed.

## Summary


### ORDER OF IMPORTANCE OF PHYSICAL THERAPY EQUIPMENT

In checking the order of importance of physical therapy equipment, there is a positive correlation throughout the Veterans' Administration Hospitals making this report. The following summary lists in the order of their importance the types of equipment needed for a physical therapy program and the disabilities or disorders for which the equipment is most effectively used.

| Equipment | Most Valuable Therapeutic Use |
|---|---|
| 1. Infra-red | Hemiplegia, arthritis, sciatic rheumatism, polio |
| 2. Diathermy | Arthritis, sciatic rheumatism, sinus (related), neuritis |
| 3. Massage table | One leg missing, one arm missing, hemiplegia, arthritis |
| 4. Whirlpool | Muscular dystrophy, polio, osteomyelitis, arthritis |
| 5. Ultra-violet | Dermatitis, sinus (related), neuritis |
| 6. Cabinet | Neuritis, arthritis |
| 7. Shoulder wheel | Neuritis, arthritis |
| 8. Stall bars | Arthritis, neuritis |
| 9. Bicycle (Stationary) | Hemiplegia, foot defects (functional) |
| 10. Faradic and Galvanic | Polio, sciatic rheumatism |
| 11. Sitz bath | Sciatic rheumatism |
| 12. Heat cradle | Arthritis |

# A Study of Degrees and Ranks Held and the Graduate Credit Offerings Taught by Men and by Women in Physical Education*

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ACCREDITING agencies and associations concerned with the scholarly attainment and professional status of graduate faculty in all fields of higher learning have, over a period time, recommended standards for individuals teaching on the graduate level. These agencies and associations in general agree that graduate faculty members should demonstrate teaching and research ability, and have a high level of scholarship. They have recommended, also, that the graduate faculty members hold doctoral degrees or the equivalent, and the rank of assistant professor or above (1–3).

In reference to terms used in this study, graduate credit offerings may be defined as strictly graduate offerings for graduate students only, in addition to those undergraduate courses identified in the catalogues of the institutions of higher learning as carrying graduate credit. The term academic degrees refers to earned degrees, such as the Doctor of Philosophy, Doctor of Education, Master of Arts, Master of Science, Bachelor of Arts, and Bachelor of Science.

The purpose of the present study was to compare the scholarly attainment and the professional status of men with that of women teaching physical education on the graduate level in universities, in colleges, and in teacher's colleges. This comparison was specifically based upon:

1. The degrees held by men and by women.
2. The faculty rank held by men and by women.
3. Graduate credit offerings taught by men and by women holding various types of degrees and ranks.

Specific studies of the scholarship and professional status of men and women teaching physical education on the graduate level were made particularly from the year 1935 to date by H. Harrison Clarke (4), Norris and Sweet (7), Jack Hewitt (6), and Loren Tuttle (8) who did much to portray the professional status of the graduate faculty. These studies dealt primarily with the degrees and faculty rank held by the graduate faculty as a whole, with little regard for division of staff into sections of men

* An abstract of a thesis for the master of science degree presented to the School of Health and Physical Education and the Graduate School, University of Oregon, August, 1949.

and of women. Although Norris and Sweet did attempt such a division, their results, according to their own admission, lacked reliability.

It seemed important that this study be undertaken to fulfill the need for more recent and reliable specific information than that presented by Norris and Sweet, and by the other studies. It makes an effort to show prevailing practices in some eighty seven institutions regarding scholarship and rank of men and of women graduate faculty members.

TABLE 1

*297 Graduate faculty members and 719 graduate credit offerings taught in 57 institutions of higher learning*

57 Institutions

| | MEN | | WOMEN | | MEN & WOMEN | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Graduate Faculty | 196 | 66.0 | 101 | 34.0 | 297 | 100.0 |
| Graduate Offerings | 484 | 67.3 | 235 | 32.7 | 719 | 100.0 |

TABLE 2

*296 Graduate faculty members teaching 718 graduate credit offerings according to type of institution*

56 Institutions*

| | UNIVERSITIES (41) | | | | | | COLLEGES (15) | | | | | | MEN & WOMEN | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | Women | | Men & Women | | Men | | Women | | Men & Women | | Universities | | Colleges | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| Graduate Faculty | 158 | 68.4 | 73 | 31.6 | 231 | 100.0 | 37 | 56.9 | 28 | 43.1 | 65 | 100.0 | 231 | 78.0 | 65 | 22.0 |
| Graduate Offerings | 372 | 70.0 | 159 | 29.9 | 531 | 100.0 | 111 | 59.3 | 76 | 40.6 | 187 | 100.0 | 531 | 73.9 | 187 | 26.1 |

* Omission of data from the Teacher's Colleges. (See Summary of Findings, item 3.)

## Source, Nature, and Treatment of Data

Data included in this study were obtained from the 1947–48 catalogues of eighty-six of the eighty-seven institutions offering graduate study programs in physical education as collected by Loren Tuttle for use in his study of graduate practices, and from short personal letters and questionnaires sent to the department heads in twenty institutions whose catalogues contained insufficient information in this respect.

The data, as shown in twelve tables of the original thesis, are on a number and percentage basis. These tables refer to the graduate staff and indicate academic degrees and faculty rank held, and graduate credit offerings taught by men and by women in the universities, in the colleges, and in the teacher's colleges.

The following four tables were selected from the original thesis on the basis of general interest and ease of reproduction.

TABLE 3

*Degrees held by 297 graduate faculty members*
*57 Institutions*

| DOCTOR'S DEGREE | | | MASTER'S DEGREE | | | BACHELOR'S DEGREE | | | DEGREE NOT GIVEN | | NO DEGREE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Degree title | No. | % | Degree title | No. | % | Degree title | No. | % | No. | % | No. | % |
| | | | | | *Men*† | | | | | | | |
| Men: No. 196 | | | | | | | | | | | | |
| M.D. | 8 | 4.1 | M.A. | 45 | 22.9 | B.A. | 14 | 7.1 | | | | |
| Ph.D. | 46 | 23.5 | M.S. | 29 | 14.8 | B.S. | 10 | 5.1 | | | | |
| Ed.D. | 17 | 8.7 | M.Ed. | 11 | 5.6 | B.P.E. | — | — | | | | |
| D.O.* | 1 | .5 | M.P.E. | 3 | 1.5 | B.E. | 1 | 0.5 | | | | |
| L.L.D. | 2 | 1.0 | | | | B.C.S. | 1 | 0.5 | | | | |
| Sc.D. | 2 | 1.0 | | | | | | | | | | |
| | | | | | | | | | 5 | 2.5 | 1 | 0.5 |
| Total | 76 | 38.8 | | 88 | 44.9 | | 26 | 13.2 | 5 | 2.5 | 1 | 0.5 |
| | | | | | *Women*† | | | | | | | |
| Women: No. 101 | | | | | | | | | | | | |
| M.D. | 3 | 2.9 | M.A. | 40 | 39.6 | B.A. | 3 | 2.9 | | | | |
| Ph.D. | 21 | 20.8 | M.S. | 18 | 17.8 | B.S. | 3 | 2.9 | | | | |
| Ed.D. | 5 | 4.9 | M.Ed. | 5 | 4.9 | B.P.E. | — | — | | | | |
| D.O.* | — | — | M.P.E. | — | — | B.E. | — | — | | | | |
| L.L.D. | — | — | | | | B.C.S. | — | — | | | | |
| Sc.D. | — | — | | | | | | | | | | |
| | | | | | | | | | 2 | 2.0 | 1 | 1.0 |
| Total | 29 | 28.7 | | 63 | 62.3 | | 6 | 5.9 | 2 | 2.0 | 1 | 1.0 |

*Degree Summary*
Men and Women

| DEGREE TITLE | TOTAL NUMBER | TOTAL PER CENT | RANK ORDER |
|---|---|---|---|
| Doctor's | 105 | 35.3 | 2 |
| Master's | 151 | 50.8 | 1 |
| Bachelor's | 32 | 10.8 | 3 |
| Degree Not Given | 7 | 2.3 | 4 |
| No Degree | 2 | 0.7 | 5 |
| Total | 297 | 100.0 | |

* Doctor of Osteopathy.
† Percentages based upon men among men and women among women.

SUMMARY OF FINDINGS

A summary of these findings shows that in general there are approximately twice as many men in institutions of higher learning teaching

twice as many graduate credit offerings as women. This same situation holds true for each separate type of institution, as university and college. In the overall percentage picture, the men and the women are in approximate equal status in respect to those who hold specific academic degrees and faculty rank, with, however, the men meeting the recommended degree and rank standard to a slightly greater extent than the women. Variations of this close equality may be noted in the breakdown of listings in the percentages of degrees and of ranks held in the universities and colleges. In greater detail the summary presents the following data:

1. More men (66%) than women (34%) are teaching graduate offerings in physical education, thus more graduate offerings are taught by men (67%) than by women (33%). However, it may be noticed that the ratio

TABLE 4

*Faculty rank held by 297 graduate faculty members*

57 Institutions

Women: No. 101 Men: No. 196

| FACULTY RANK | MEN† | | WOMEN† | | MEN & WOMEN | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Professor | 75 | 38.3 | 24 | 23.8 | 99 | 33.3 |
| Associate | 39 | 19.9 | 23 | 22.8 | 62 | 20.9 |
| Assistant | 43 | 21.9 | 27 | 26.7 | 70 | 23.6 |
| Instructor | 23 | 11.7 | 16 | 15.8 | 39 | 13.1 |
| Other* | 12 | 6.1 | 10 | 9.9 | 22 | 7.4 |
| Rank Not Given | 4 | 2.0 | 1 | 1.0 | 5 | 1.7 |
| Total | 196 | 100.0 | 101 | 100.0 | 297 | 100.0 |

* Lecturer, Supervisor, Assistant and Associate in Physical Education, Part-time and Visiting Instructor.

† Percentages based upon men among men and women among women.

between individuals teaching and offerings taught remains approximately the same in the case of both the men and the women (Table 1).

2. A greater percentage of graduate instructors, men and women, are on university faculties (78%) than on college faculties (22%), likewise, more graduate offerings are taught in universities (74%) than in colleges (26%). It can thus be seen that the college faculties are responsible for more offerings per instructor than are the university faculties. (Table 2).

3. No comparative percentages of degrees, faculty rank, and graduate offerings could be obtained from data available from the teacher's colleges because of insufficient information contained in the catalogues of those institutions.

4. The graduate faculty men came closer to meeting the degree standard recommended by the agencies and associations concerned with graduate programs than did women. (*Doctor's Degree:* men 39%, women 29%; *Master's Degree:* men 45%, women 62%; *Bachelor's Degree:* men 13%, women 6%.) The men also came closer to meeting the recommended faculty

rank standard than did the women. (*Professor, Associate Professor, and Assistant Professor Rank:* men 80%, women 73%.) (Tables 3 & 4.)

5. The graduate faculty, men and women, came much closer to meeting the recommended standard of rank than of degrees. (Tables 3 & 4).

6. With respect to graduate credit offerings taught, men came closer to meeting the degree standard than women. (*Doctor's Degree:* offerings taught by men 51%, by women 34%; *Master's Degree:* offerings taught by men 38%, by women 58%; *Bachelor's Degree:* offerings taught by men 9%, by women 5%.) Likewise, concerning graduate offerings taught, men came closer to meeting the rank standard than did women. (*Professor, Associate Professor, and Assistant Professor:* offerings taught by men 86%, by women 77%.

7. In relation to the above mentioned graduate offerings, the men and the women came much closer to meeting the recommended standard of faculty rank than of academic degrees. (Refer to item 6.)

8. The university faculty men came closer to meeting the degree standard than the college women, the university women, and the college men. (*Doctor's Degree:* university men 43%, college women 39%, university women 25%, college men 19%; *Master's Degree:* university men 42%, college women 54%, university women 66%, college men 59%; *Bachelor's Degree:* university men 13%, college women 0%, university women 8%, college men 16%.) Concerning the college men and the college women, it may be stated that they came closer to meeting the recommended rank standard than the university men and the university women. (*Professor, Associate Professor, and Assistant Professor Rank:* college men 86%, college women 86%, university men 78%, university women 68%.)

9. In reference to graduate credit offerings taught, the university faculty men came closer to meeting the degree standard than did the college women, the university women, and the college men. (*Doctor's Degree:* offerings taught by university men 56%, by college women 43%, by university women 29%, by college men 34%; *Master's Degree:* offerings taught by university men 35%, by college women 51%, by university women 62%, by college men 49%; *Bachelor's Degree:* offerings taught by university men 8%, by college women 0%, by university women 8%, by college men 11%.) Whereas, with respect to faculty rank, the college faculty, men and women, came closer to meeting the recommended standard than the university faculty, men and women. (*Professor, Associate Professor, and Assistant Professor Rank:* offerings taught by college men 91%, by college women 84%, by university men 84%, by university women 74%.)

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# The Acute Effect of Smoking Upon the Physical Performance of Habitual Smokers

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DOES SMOKING hinder athletic performance? Many coaches and trainers say that it does while others in the field of athletics maintain that there is no immediate effect from smoking. Previous studies show variable effect of smoking upon speed and accuracy of manipulative activities (1, 2, 4–6). Smoking was shown to prolong recovery after double periods of work using a hand dynamometer (10). When this study was repeated using more careful controls, no effect on recovery due to smoking was noted (7). These studies are summarized in Table 1.

## PROBLEM

It was the purpose of this investigation to study the acute effect of smoking upon some of the physiological components of athletic performance in habitual smokers.

## METHOD

In order to study the acute effect of smoking upon the physical performance of habitual smokers, fifteen college students who were habitual smokers volunteered as subjects for the study. Fourteen of the subjects were men and one was a woman. Tests of speed, strength, agility, and endurance were administered to all subjects under two conditions. Condition (a) was a non-smoking period two hours prior to the test. Condition (b) was inhaling 2.7 liters of smoke from one cigarette.

## APPARATUS

In order to control the amount of smoke inhaled by the subjects during the experiment, a smoking device was constructed. This device is shown in Figure I. It consisted of a mouthpiece (*g*) connected to a chamber (*e*) containing flutter valves (*d*) which directed the flow of smoke through an aperture (*f*) into the subject's respiratory cavity upon inhalation. During exhalation, the expired air passed through a tube connecting the pipe (*h*) with a gasometer. A lighted cigarette was placed in the aperture of the smoking device (*a*). The subject inhaled smoke through the cigarette which was mixed with air drawn through the small opening (*b*) at the end of the device. Most of the subjects consumed three-fourths of a cigarette during the process which required three to four minutes. The location of the right intake valve (*d*) prevented exhaled air from increasing the com-

TABLE 1

*Summary of studies of the acute effect of smoking on physical performance*

| TEST | RESULTS AFTER SMOKING | REFERENCE |
|---|---|---|
| Speed and accuracy of sorting playing cards | Slight decrease in accuracy | Carver (2) |
| Accuracy of throwing darts | Negligible to slight decrease of accuracy | Bates (1) |
| Prolonged tapping of telegraph key at maximum rate | Slight increase in speed and endurance | Hull (6) |
| Speed and accuracy of simple and choice reactions to colored lights | Increased speed and accuracy | Fisher (5) |
| Repeated measurement of grip strength. Non-smoking test administered 2 days after smoking test | Lower degree of recovery after smoking. (May be ascribed to beneficial effect of training on non-smoking test) | Willgoose (10) |
| Repetition of Willgoose study. Used placebo and randomized series. | No effect on recovery from fatigue. | Kay and Karpovich (7) |

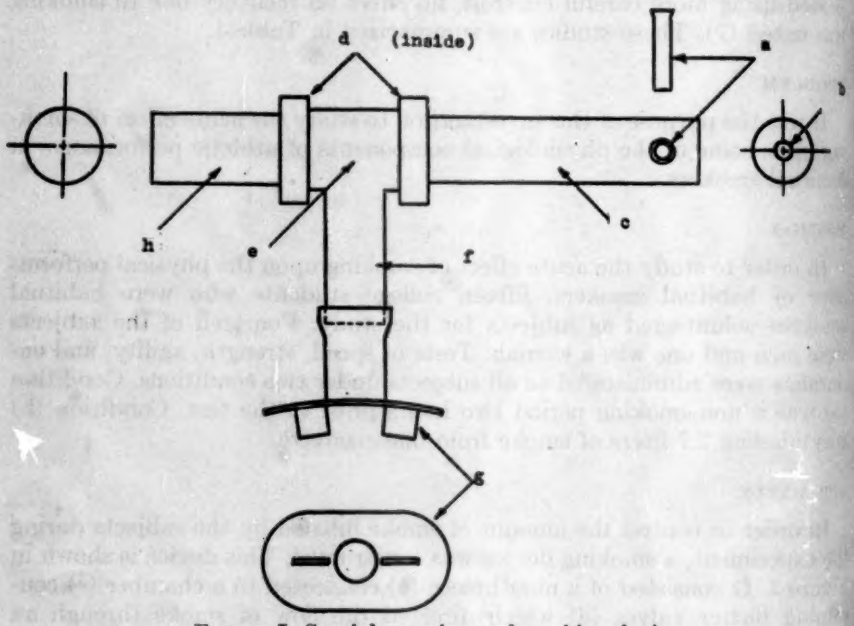


FIGURE I. Special experimental smoking device
a—cigarette holder
b—air opening
c—air intake pipe
d—flutter valves (rubber)
e—valve chamber
f—mouth pipe
g—mouth piece (rubber)
h—air escape pipe all parts brass except those noted
Scale: 0.5″ equal 1.0″

bustion of the cigarette. The subjects reported irritation of the upper respiratory tract during and immediately after smoking. It was observed that the subjects increased salivation markedly during smoking.

PROCEDURE

Each subject reported to the laboratory on alternate successive days at approximately the same time. The activity of each subject preceding the test sessions was identical. The subject was seated and connected to the smoking apparatus. On the non-smoking day (condition a) the cigarette in the device was unlighted. On the smoking day (condition b) the cigarette was lighted. The order of conditions (a) and (b) was alternated to control as far as possible the effects of fatigue, training, and familiarity with the procedure. In each instance, after 2.7 liters of gas had been exhaled into

TABLE 2

*Summary of Variation among test scores in the two conditions of non-smoking and smoking before performance*

| TEST | MEAN SCORES | | DIFFERENCE BETWEEN NON-SMOKE AND SMOKE | "t" | LEVEL OF CONFIDENCE |
|---|---|---|---|---|---|
| | Non-smoke | Smoke | | | |
| | | | | | % |
| Tapping (taps per sec.) | 9.5 | 9.3 | 0.2 | 0.833 | 40 |
| Sargent Jump (inches) | 24.1 | 24.0 | 0.1 | 0.415 | 70 |
| Grip Strength (kgs.) | 78.2 | 78.6 | —0.4 | 0.289 | 80 |
| Push Strength (pounds) | 93.2 | 92.4 | 0.8 | 0.352 | 70 |
| Step Test Score (points) | 70.3 | 68.3 | 2.0 | 0.729 | 50 |
| Pulse Rate after Step Test (per 30 secs.) | 65.6 | 68.6 | —3.0 | 0.958 | 40 |
| Duration of Stepping Exercise | 250.0 | 257.0 | —7.0 | 0.786 | 40 |

the gasometer, the subject was disconnected from the apparatus and was given the physical performance tests.

TESTS

A battery of tests of physical performance was administered in the order in which they are described below:

*The tapping test*, a test of speed of voluntary movements, was used to measure the functional condition of the central nervous system. The subjects tapped a telegraph key as rapidly as possible for five seconds. The taps were recorded on a moving kymograph upon which one-second time marks had been previously recorded. The highest rate during any one second was recorded as the rate of tapping.

*Strength* was measured by recording maximum efforts on a grip and a push dynamometer using standard procedures (3). Each subject was allowed five trials on each instrument. The highest reading was recorded in both instances.

*The Sargent Jump* was used to measure muscular power, or the ability to exert a large force in a short time. The jump and reach type of apparatus was used in the conventional form (8).

*The Short Form of the Harvard Step Test* (9) was employed to measure endurance of the subjects and to measure the degree of displacement of physiological homeostasis.

## RESULTS

A statistical summary of the results of the tests given under the two conditions of the experiment appears in Table 2. The test scores achieved under the two conditions were compared. None of the scores showed a statistical difference or a level of confidence high enough to indicate the smoking before the tests had any immediate effect upon performance.

## SUMMARY AND CONCLUSIONS

Fifteen habitual smokers inhaled cigarette smoke just before performing tests of speed, strength, power, and endurance. They repeated the tests after refraining from smoking. The results of the tests support the following conclusions:

1. Smoking does not appear to have any influence upon the performance of any of the tests of maximum rate of voluntary movement, muscular strength and power, or cardiovascular fitness for strenuous endurance type of exercise.

2. Apparently, if a person is a habitual smoker, it makes no difference in his physical performance whether he abstains from smoking for a few hours before performing or whether he smokes up to the start of the event.

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# Grip Strength Norms for Males

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IT IS THE purpose of this study to analyze male grip strengths by age, by weight classes, and by Classification Index[1] groupings.

Grip strength is one of the most reliable dynamometrical measures of human strength. It is a relatively economical measure, is easily administered and is a direct measure of applied force. Accordingly grip strength is a likely component of strength batteries, a strength item in a "fitness" battery, or single item reasonably representative of total body strength.

Profiles were made of the mean and standard deviation through each interval in the age, weight classes, and Classification Index divisions, to show graphically the relationship of increased age, weight, and Classification Index to grip strength. The standard deviation limits are indicated by dotted lines.

Achievement scales have been established for each hand for each age from 9 to 24 and up; for weight groups from up to 69 pounds and to 210 pounds and up, in decile groups; and for Classification Index I groups from up to 594 to 980 and up, in intervals of 35 points of Index. There is evidence that norms should be established for Wetzel's[2] developmental levels and physique classifications, but this awaits further study. No effort has been made to indicate a superior basis for classifying for grip strength. Instead, it is the object of this study to make norms available by age, weight, and Classification Index.

The six sigma formula is employed in each scale and the frequencies for all aspects of the study follow. In this procedure the mean is set at 50 scale score points and the raw score equivalent for each scale score is determined as indicated at the top of each scale.

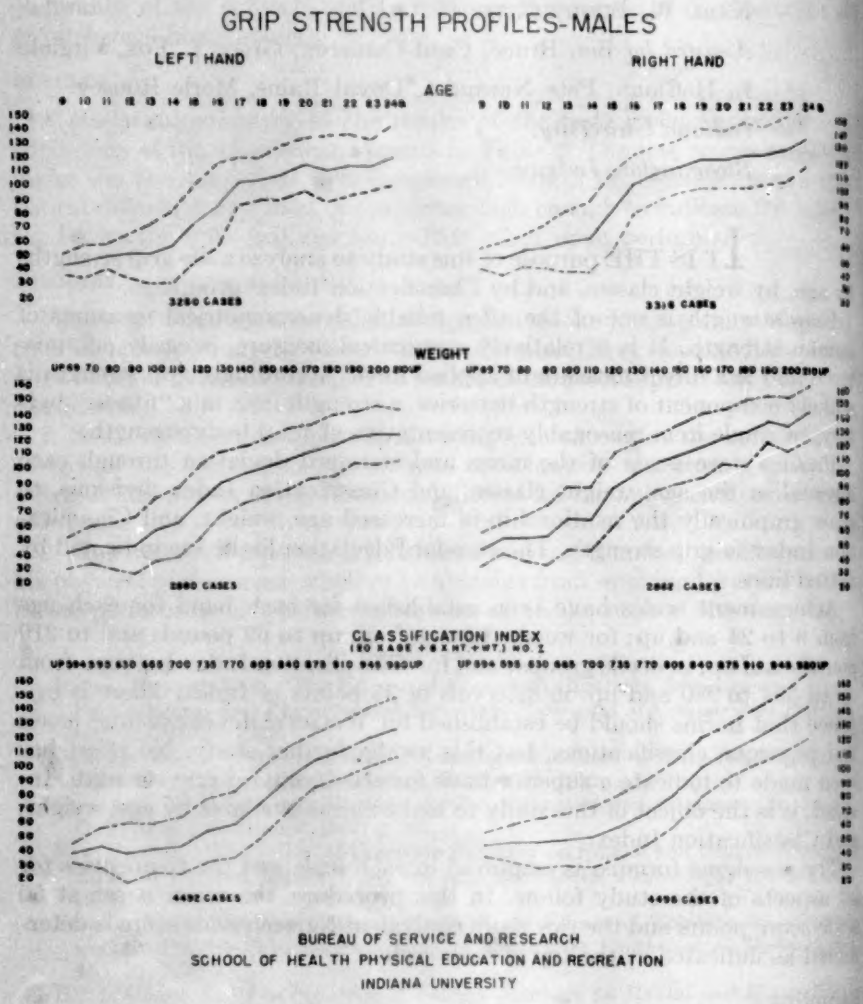
## Sampling

The data for this study were collected from several states (Colorado, Illinois, Indiana, Kentucky, and Missouri) and aspects of the study were undertaken by the several authors at different times. The frequencies are

[1] Charles H. McCloy, *The Measurement of Athletic Power*, A. S. Barnes and Company, New York, 1932, p. 119.

[2] Norman C. Wetzel, *Instruction Manual In the Use of the Grid for Evaluating Physical Fitness*. N. E. A. Service, Cleveland, 1941.

not the same for the diffcrent parts of the study but it is felt that a sufficient sample is involved in any mean or deviation to give reasonable assurance of practicable stability to the scales.




LEFT GRIP STRENGTH OF MALES BY AGE

The left mean grip strength of males from ages 9 through 24 and up tends generally to increase with age. Slight progression occurs in mean grip strength from ages 9 to 14. Progression accelerates from 14 to 17 years with the greatest increases at 16 and 17 years. A few small irregularities in mean strength appear between 17 and 24 years and up when progression is

slower. But a plateau starts at approximately 17 years of age. The 9 year olds have the smallest mean grip strength, 42 pounds, and the oldest men have the greatest mean grip strength, 121 pounds.

Left hand grip by age shows more irregularity and varied variability than the right hand grip. The least variability and the smallest mean grip strength is between the ages of 9 to 11, where the number of cases is small. Wider variability occurs from 12 years on with the greatest variability during the 14 to 17 years range of mean strength acceleration. The 14 to 17 years range includes the rapid growth years. The left hand mean grip strengths are less than the right hand mean grip strengths for every age group. The difference at regular increments ranges from 5 to 14 pounds.

*Frequencies of cases in various age, weight, and classification index groups*

Age

| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24-UP | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LH | 35 | 48 | 62 | 178 | 340 | 523 | 386 | 251 | 269 | 502 | 237 | 103 | 98 | 95 | 38 | 85 | 3250 |
| RH | 36 | 49 | 63 | 188 | 346 | 501 | 393 | 264 | 270 | 516 | 226 | 130 | 104 | 115 | 41 | 74 | 3316 |

Weight

| | UP TO 69 | 70-9 | 80-9 | 90-9 | 100-9 | 110-9 | 120-9 | 130-9 | 140-9 | 150-9 | 160-9 | 170-9 | 180-9 | 190-9 | 200-9 | 210-UP | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LH | 73 | 126 | 203 | 292 | 278 | 280 | 349 | 359 | 270 | 214 | 144 | 101 | 60 | 45 | 35 | 31 | 2860 |
| RH | 73 | 126 | 203 | 292 | 278 | 280 | 351 | 358 | 270 | 214 | 145 | 101 | 60 | 45 | 35 | 31 | 2862 |

Classification Index I

| | UP TO 594 | 595-629 | 630-64 | 665-99 | 700-34 | 735-69 | 770-804 | 805-39 | 840-74 | 875-909 | 910-44 | 945-79 | 980-UP | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LH | 35 | 55 | 113 | 213 | 291 | 339 | 327 | 334 | 521 | 1027 | 837 | 318 | 82 | 4492 |
| RH | 35 | 55 | 112 | 213 | 291 | 339 | 327 | 334 | 521 | 1028 | 838 | 321 | 82 | 4496 |

RIGHT GRIP STRENGTH OF MALES BY AGE

The right mean grip strength of males from ages 9 through 24 and up tends generally to increase with age. Slow, regular progression in mean grip strength occurs from ages 9 to 14. Progression accelerates from 14 through 16 years with the greatest increase at 16 years. Beyond 16 years progression is slower, but regular through 23 years, with a rise occurring at the last interval, 24 years and up. However, there tends to be a plateau beyond 16 years, although less pronounced than for the left hand. Right hand mean grip strength by age shows less irregularity in progression than the left hand grip. The least variability is at the 9 year old interval, where the number of cases is small. Wider variability occurs from 13 years on. The 9 and 10 year olds have the smallest mean grip strengths, 43 pounds and 49 pounds, and the oldest men have the greatest mean grip strengths, 135 pounds. After 14 years the variability of the age groups differ only slightly.

*6σ/100 left grip strength scales for males by age*

| SCALE SCORE | AGE | | | | | | | | | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
| 100 | 65 | 78 | 76 | 95 | 112 | 130 | 154 | 175 | 154 | 148 | 166 | 170 | 181 | 180 | 169 | 183 | 100 |
| 99 | 64 | | | 94 | 111 | 128 | 153 | 173 | 153 | 147 | 165 | 169 | 179 | 178 | 168 | 182 | 99 |
| 98 | | 77 | 75 | 93 | 109 | 127 | 151 | 171 | 152 | 146 | 164 | 168 | 178 | 177 | 167 | 181 | 98 |
| 97 | | 76 | | 92 | 108 | 125 | 150 | 169 | 151 | | 163 | 166 | 176 | 176 | 166 | 180 | 97 |
| 96 | 63 | | 74 | 91 | 107 | 124 | 148 | 167 | 150 | 145 | 162 | 165 | 175 | 174 | 165 | 178 | 96 |
| 95 | | 75 | | 90 | 106 | 122 | 145 | 166 | 149 | 144 | 160 | 164 | 174 | 173 | 164 | 177 | 95 |
| 94 | 62 | 74 | 73 | 89 | 104 | 120 | 145 | 164 | 148 | 143 | 159 | 163 | 172 | 172 | 163 | 176 | 94 |
| 93 | | | 72 | 88 | 103 | 119 | 143 | 162 | 147 | 142 | 158 | 162 | 170 | 170 | 162 | 175 | 93 |
| 92 | 61 | 73 | | 87 | 102 | 118 | 141 | 160 | 146 | 141 | 157 | 161 | 169 | 169 | 161 | 173 | 92 |
| 91 | | 72 | 71 | 86 | 101 | 116 | 140 | 158 | 145 | 140 | 156 | 160 | 168 | 168 | 159 | 172 | 91 |
| 90 | 60 | | | | 100 | 115 | 138 | 157 | 144 | 139 | 154 | 159 | 167 | 167 | 158 | 171 | 90 |
| 89 | | 71 | 70 | 85 | 98 | 113 | 136 | 155 | 142 | 138 | 153 | 157 | 165 | 165 | 157 | 170 | 89 |
| 88 | 59 | 70 | | 84 | 97 | 112 | 135 | 153 | 141 | | 152 | 156 | 164 | 164 | 156 | 168 | 88 |
| 87 | | | 69 | 83 | 96 | 110 | 133 | 151 | 140 | 137 | 151 | 155 | 162 | 163 | 155 | 167 | 87 |
| 86 | | 69 | | 82 | 95 | 109 | 131 | 150 | 139 | 136 | 150 | 154 | 161 | 161 | 154 | 166 | 86 |
| 85 | 58 | 68 | 68 | 81 | 93 | 107 | 130 | 148 | 138 | 135 | 149 | 153 | 160 | 160 | 153 | 165 | 85 |
| 84 | | | 67 | 80 | 92 | 106 | 128 | 146 | 137 | 134 | 148 | 152 | 158 | 159 | 152 | 163 | 84 |
| 83 | 57 | 67 | | 79 | 91 | 104 | 127 | 144 | 136 | 133 | 146 | 151 | 157 | 157 | 151 | 162 | 83 |
| 82 | | 66 | 66 | 78 | 90 | 103 | 125 | 142 | 135 | 132 | 145 | 150 | 156 | 156 | 150 | 161 | 82 |
| 81 | 56 | | | 77 | 88 | 101 | 123 | 141 | 134 | 131 | 144 | 149 | 154 | 155 | 148 | 160 | 81 |
| 80 | | 65 | 65 | | 87 | 100 | 122 | 139 | 133 | 130 | 143 | 148 | 153 | 153 | 147 | 158 | 80 |
| 79 | 55 | 64 | | 76 | 86 | 99 | 120 | 137 | 132 | | 142 | 147 | 151 | 152 | 146 | 157 | 79 |
| 78 | | 63 | 64 | 75 | 85 | 97 | 118 | 135 | 131 | 129 | 141 | 146 | 150 | 151 | 145 | 156 | 78 |
| 77 | 54 | | 63 | 74 | 84 | 96 | 117 | 134 | 130 | 128 | 139 | 144 | 148 | 149 | 144 | 155 | 77 |
| 76 | | 62 | | 73 | 82 | 94 | 115 | 132 | 129 | 127 | 138 | 143 | 147 | 148 | 143 | 153 | 76 |
| 75 | | 61 | 62 | 72 | 81 | 93 | 113 | 130 | 128 | 126 | 137 | 142 | 146 | 147 | 142 | 152 | 75 |
| 74 | 53 | | | 71 | 80 | 91 | 112 | 128 | 127 | 125 | 136 | 141 | 144 | 145 | 141 | 151 | 74 |
| 73 | | 60 | 61 | 70 | 79 | 90 | 110 | 126 | 126 | 124 | 135 | 140 | 143 | 144 | 140 | 150 | 73 |
| 72 | 52 | 59 | | 69 | 77 | 88 | 109 | 125 | 125 | 123 | 134 | 139 | 142 | 143 | 139 | 148 | 72 |
| 71 | | | 60 | 68 | 76 | 87 | 107 | 123 | 124 | 122 | 132 | 138 | 140 | 141 | 137 | 147 | 71 |
| 70 | 51 | 58 | | | 75 | 85 | 105 | 121 | 123 | | 131 | 137 | 139 | 140 | 136 | 146 | 70 |
| 69 | | 57 | 59 | 67 | 74 | 84 | 104 | 119 | 122 | 121 | 130 | 136 | 137 | 139 | 135 | 145 | 69 |
| 68 | 50 | | 58 | 66 | 72 | 82 | 102 | 118 | 121 | 120 | 129 | 134 | 136 | 137 | 134 | 143 | 68 |
| 67 | | 56 | | 65 | 71 | 81 | 100 | 116 | 120 | 119 | 128 | 133 | 135 | 137 | 133 | 142 | 67 |
| 66 | | | 57 | 64 | 70 | 79 | 99 | 114 | 119 | 118 | 127 | 132 | 133 | 135 | 132 | 141 | 66 |
| 65 | 49 | 55 | | 63 | 69 | 78 | 97 | 112 | 118 | 117 | 126 | 131 | 132 | 133 | 131 | 140 | 65 |
| 64 | | 54 | 56 | 62 | 68 | 76 | 95 | 110 | 117 | 116 | 124 | 130 | 130 | 132 | 130 | 138 | 64 |
| 63 | 48 | 53 | | 61 | 66 | 75 | 94 | 109 | 116 | 115 | 123 | 129 | 129 | 131 | 129 | 137 | 63 |
| 62 | | | 55 | 60 | 65 | 73 | 92 | 107 | 115 | 114 | 122 | 128 | 128 | 129 | 128 | 136 | 62 |
| 61 | 47 | 52 | 54 | 59 | 64 | 72 | 90 | 105 | 114 | | 121 | 127 | 126 | 128 | 126 | 135 | 61 |
| 60 | | 51 | | | 63 | 70 | 89 | 103 | 113 | 113 | 120 | 126 | 125 | 127 | 125 | 133 | 60 |
| 59 | 46 | | 53 | 58 | 61 | 69 | 87 | 102 | 112 | 112 | 118 | 125 | 124 | 126 | 124 | 132 | 59 |
| 58 | | 50 | | 57 | 60 | 67 | 86 | 100 | 111 | 111 | 117 | 124 | 122 | 124 | 123 | 131 | 58 |
| 57 | 45 | 49 | 52 | 56 | 59 | 66 | 84 | 98 | 110 | 110 | 116 | 122 | 121 | 123 | 122 | 130 | 57 |
| 56 | | | | 55 | 58 | 64 | 82 | 96 | 108 | 109 | 115 | 121 | 119 | 122 | 121 | 128 | 56 |
| 55 | | 48 | 51 | 54 | 56 | 63 | 81 | 94 | 107 | 108 | 114 | 120 | 118 | 120 | 120 | 127 | 55 |
| 54 | 44 | 47 | | 53 | 55 | 62 | 79 | 93 | 106 | 107 | 113 | 119 | 116 | 119 | 119 | 126 | 54 |
| 53 | | | 50 | 52 | 54 | 60 | 77 | 91 | 105 | 106 | 112 | 118 | 115 | 118 | 118 | 125 | 53 |
| 52 | 43 | 46 | 49 | 51 | 53 | 59 | 76 | 89 | 104 | | 110 | 117 | 114 | 116 | 117 | 123 | 52 |
| 51 | | | | 50 | 51 | 57 | 74 | 87 | 103 | 105 | 109 | 116 | 112 | 115 | 115 | 122 | 51 |

*6σ/100 left grip strength scales for males by age*

| SCALE SCORE | AGE | | | | | | | | | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
| 50 | 42 | | 48 | 49 | 50 | 56 | 72 | 86 | 102 | 104 | 108 | 115 | 111 | 114 | 114 | 121 | 50 |
| 49 | | 44 | | | 49 | 54 | 71 | 84 | 101 | 103 | 107 | 114 | 110 | 112 | 113 | 120 | 49 |
| 48 | 41 | 43 | 47 | 48 | 48 | 53 | 69 | 82 | 100 | 102 | 106 | 112 | 108 | 111 | 112 | 118 | 48 |
| 47 | | | | 47 | 47 | 51 | 68 | 80 | 99 | 101 | 105 | 111 | 107 | 110 | 111 | 117 | 47 |
| 46 | 40 | 42 | 46 | 46 | 45 | 50 | 66 | 78 | 98 | 100 | 104 | 110 | 105 | 108 | 110 | 116 | 46 |
| 45 | | 41 | 45 | 45 | 44 | 48 | 64 | 77 | 97 | 99 | 102 | 109 | 104 | 107 | 109 | 115 | 45 |
| 44 | | | | 44 | 43 | 47 | 63 | 75 | 96 | | 101 | 108 | 103 | 106 | 108 | 113 | 44 |
| 43 | 39 | 40 | 44 | 43 | 42 | 45 | 61 | 73 | 95 | 98 | 100 | 107 | 101 | 104 | 107 | 112 | 43 |
| 42 | | 39 | | 42 | 40 | 44 | 59 | 71 | 94 | 97 | 99 | 106 | 100 | 103 | 106 | 111 | 42 |
| 41 | 38 | | 43 | 41 | 39 | 42 | 58 | 70 | 93 | 96 | 98 | 105 | 98 | 102 | 104 | 110 | 41 |
| 40 | | 38 | | | 38 | 41 | 56 | 68 | 92 | 95 | 96 | 104 | 97 | 100 | 103 | 108 | 40 |
| 39 | 37 | 37 | 42 | 40 | 37 | 39 | 54 | 66 | 91 | 94 | 95 | 103 | 96 | 99 | 102 | 107 | 39 |
| 38 | | | | 39 | 36 | 38 | 53 | 64 | 90 | 93 | 94 | 102 | 94 | 98 | 101 | 106 | 38 |
| 37 | 36 | 36 | 41 | 38 | 34 | 36 | 51 | 62 | 89 | 92 | 93 | 100 | 93 | 96 | 100 | 105 | 37 |
| 36 | | 35 | 40 | 37 | 33 | 35 | 50 | 61 | 88 | 91 | 92 | 99 | 92 | 95 | 99 | 103 | 36 |
| 35 | 35 | | | 36 | 32 | 33 | 48 | 59 | 87 | | 91 | 98 | 90 | 94 | 98 | 102 | 35 |
| 34 | | 34 | 39 | 35 | 31 | 32 | 46 | 57 | 86 | 90 | 90 | 97 | 89 | 92 | 97 | 101 | 34 |
| 33 | | 33 | | 34 | 29 | 30 | 45 | 55 | 85 | 89 | 88 | 96 | 87 | 91 | 96 | 100 | 33 |
| 32 | 34 | | 38 | 33 | 28 | 29 | 43 | 53 | 84 | 88 | 87 | 95 | 86 | 90 | 95 | 98 | 32 |
| 31 | | 32 | | 32 | 27 | 27 | 42 | 52 | 83 | 87 | 86 | 94 | 85 | 88 | 93 | 97 | 31 |
| 30 | 33 | 31 | 37 | | 26 | 26 | 40 | 50 | 82 | 86 | 85 | 93 | 83 | 87 | 92 | 96 | 30 |
| 29 | | | 36 | 31 | 24 | 24 | 38 | 48 | 81 | 85 | 84 | 92 | 82 | 86 | 91 | 95 | 29 |
| 28 | 32 | 30 | | 30 | 23 | 23 | 37 | 46 | 80 | 84 | 83 | 90 | 80 | 84 | 90 | 93 | 28 |
| 27 | | 29 | 35 | 29 | 22 | 22 | 35 | 45 | 79 | 83 | 81 | 89 | 79 | 83 | 89 | 92 | 27 |
| 26 | 31 | | | 28 | 21 | 20 | 34 | 43 | 78 | | 80 | 88 | 78 | 82 | 88 | 91 | 26 |
| 25 | | 28 | 34 | 27 | 20 | 19 | 32 | 41 | 77 | 82 | 79 | 87 | 76 | 81 | 87 | 90 | 25 |
| 24 | 30 | 27 | | 26 | 18 | 17 | 30 | 39 | 76 | 81 | 78 | 86 | 75 | 79 | 86 | 88 | 24 |
| 23 | | | 33 | 25 | 17 | 16 | 29 | 37 | 74 | 80 | 77 | 85 | 74 | 78 | 85 | 87 | 23 |
| 22 | | 26 | | 24 | 16 | 14 | 27 | 36 | 73 | 79 | 76 | 84 | 72 | 77 | 84 | 86 | 22 |
| 21 | 29 | 25 | 32 | 23 | 15 | 13 | 26 | 34 | 72 | 78 | 74 | 83 | 71 | 75 | 82 | 85 | 21 |
| 20 | | | 31 | | 13 | 11 | 24 | 32 | 71 | 77 | 73 | 82 | 69 | 74 | 81 | 83 | 20 |
| 19 | 28 | 24 | | 22 | 12 | 10 | 22 | 30 | 70 | 76 | 72 | 81 | 68 | 73 | 80 | 82 | 19 |
| 18 | | 23 | 30 | 21 | 11 | 8 | 21 | 29 | 69 | 75 | 71 | 80 | 66 | 71 | 79 | 81 | 18 |
| 17 | 27 | 22 | | 20 | 10 | 7 | 19 | 27 | 68 | | 70 | 78 | 65 | 70 | 78 | 80 | 17 |
| 16 | | | 29 | 19 | 8 | 5 | 18 | 25 | 67 | 74 | 69 | 77 | 64 | 69 | 77 | 78 | 16 |
| 15 | 26 | 21 | | 18 | 7 | 4 | 16 | 23 | 66 | 73 | 68 | 76 | 62 | 67 | 76 | 77 | 15 |
| 14 | | 20 | 28 | 17 | 6 | 2 | 14 | 21 | 65 | 72 | 66 | 75 | 61 | 66 | 75 | 76 | 14 |
| 13 | 25 | | 27 | 16 | 5 | 1 | 13 | 20 | 64 | 71 | 65 | 74 | 60 | 65 | 74 | 75 | 13 |
| 12 | | 19 | | 15 | 4 | | 11 | 18 | 63 | 70 | 64 | 73 | 58 | 63 | 73 | 73 | 12 |
| 11 | 24 | 18 | 26 | 14 | 2 | | 10 | 16 | 62 | 69 | 63 | 72 | 57 | 62 | 71 | 72 | 11 |
| 10 | | | | | 1 | | 8 | 14 | 61 | 68 | 62 | 71 | 55 | 61 | 70 | 71 | 10 |
| 9 | | 17 | 25 | 13 | | | 6 | 13 | 60 | 67 | 60 | 70 | 54 | 59 | 69 | 70 | 9 |
| 8 | 23 | 16 | | 12 | | | 5 | 11 | 59 | | 59 | 68 | 53 | 58 | 68 | 68 | 8 |
| 7 | | | 24 | 11 | | | 3 | 9 | 58 | 66 | 58 | 67 | 51 | 57 | 67 | 67 | 7 |
| 6 | 22 | 15 | 23 | 10 | | | 2 | 7 | 57 | 65 | 57 | 66 | 50 | 55 | 66 | 66 | 6 |
| 5 | | 14 | | 9 | | | 1 | 5 | 56 | 64 | 56 | 65 | 48 | 54 | 65 | 65 | 5 |
| 4 | 21 | | 22 | 8 | | | | 4 | 55 | 63 | 55 | 64 | 47 | 53 | 64 | 63 | 4 |
| 3 | | 13 | | 7 | | | | 2 | 54 | 62 | 54 | 63 | 46 | 51 | 63 | 62 | 3 |
| 2 | 20 | 12 | 21 | 6 | | | | | 53 | 61 | 52 | 62 | 44 | 50 | 62 | 61 | 2 |
| 1 | | | | 5 | | | | | 52 | 60 | 51 | 60 | 43 | 49 | 60 | 60 | 1 |

*6σ/100 right grip strength scales for males by age*

| SCALE SCORE | AGE | | | | | | | | | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
| 100 | 71 | 84 | 86 | 101 | 124 | 138 | 167 | 166 | 169 | 171 | 182 | 179 | 191 | 184 | 195 | 193 | 100 |
| 99 | 70 | 83 | | | 123 | 136 | 165 | 165 | 168 | 170 | 181 | 178 | 190 | 182 | 194 | 191 | 99 |
| 98 | | | 85 | 100 | 121 | 135 | 163 | 164 | 167 | 169 | 179 | 177 | 188 | 181 | 192 | 190 | 98 |
| 97 | | 82 | 84 | 99 | 120 | 133 | 162 | 162 | 166 | 168 | 178 | 176 | 187 | 180 | 191 | 189 | 97 |
| 96 | 69 | 81 | | 98 | 119 | 132 | 160 | 161 | 164 | 167 | 177 | 175 | 186 | 179 | 190 | 188 | 96 |
| 95 | | | 83 | 97 | 118 | 130 | 158 | 160 | 163 | 165 | 176 | 173 | 184 | 178 | 188 | 187 | 95 |
| 94 | 68 | 80 | 82 | 96 | 116 | 129 | 157 | 159 | 162 | 164 | 174 | 172 | 183 | 176 | 187 | 186 | 94 |
| 93 | | 79 | | 95 | 115 | 127 | 155 | 157 | 161 | 163 | 173 | 171 | 181 | 175 | 185 | 185 | 93 |
| 92 | 67 | | 81 | 94 | 114 | 126 | 153 | 156 | 160 | 162 | 172 | 170 | 180 | 174 | 184 | 183 | 92 |
| 91 | | 78 | 80 | 93 | 112 | 124 | 152 | 155 | 158 | 161 | 171 | 169 | 179 | 173 | 183 | 182 | 91 |
| 90 | 66 | 77 | | 92 | 111 | 123 | 150 | 153 | 157 | 160 | 169 | 167 | 177 | 171 | 181 | 181 | 90 |
| 89 | | 76 | 79 | | 110 | 121 | 148 | 152 | 156 | 159 | 168 | 166 | 176 | 170 | 180 | 180 | 89 |
| 88 | 65 | | 78 | 91 | 109 | 120 | 147 | 151 | 155 | 157 | 167 | 165 | 174 | 169 | 179 | 179 | 88 |
| 87 | | 75 | | 90 | 107 | 118 | 145 | 149 | 154 | 156 | 166 | 164 | 173 | 168 | 177 | 178 | 87 |
| 86 | 64 | 74 | 77 | 89 | 106 | 117 | 143 | 148 | 152 | 155 | 164 | 163 | 172 | 167 | 176 | 176 | 86 |
| 85 | | | 76 | 88 | 105 | 115 | 141 | 147 | 151 | 154 | 163 | 161 | 170 | 165 | 175 | 175 | 85 |
| 84 | | 73 | | 87 | 103 | 114 | 140 | 146 | 150 | 153 | 162 | 160 | 169 | 164 | 173 | 174 | 84 |
| 83 | 63 | 72 | 75 | 86 | 102 | 112 | 138 | 144 | 149 | 152 | 161 | 159 | 168 | 163 | 172 | 173 | 83 |
| 82 | | 71 | | 85 | 101 | 111 | 136 | 143 | 148 | 151 | 159 | 158 | 166 | 162 | 171 | 172 | 82 |
| 81 | 62 | | 74 | 84 | 100 | 109 | 135 | 142 | 146 | 149 | 158 | 157 | 165 | 160 | 169 | 171 | 81 |
| 80 | | 70 | 73 | 83 | 98 | 108 | 133 | 140 | 145 | 148 | 157 | 155 | 163 | 159 | 168 | 169 | 80 |
| 79 | 61 | 69 | | 82 | 97 | 106 | 131 | 139 | 144 | 147 | 156 | 154 | 162 | 158 | 166 | 168 | 79 |
| 78 | | | 72 | | 96 | 105 | 130 | 138 | 143 | 146 | 154 | 153 | 161 | 157 | 165 | 167 | 78 |
| 77 | 60 | 68 | 71 | 81 | 95 | 103 | 128 | 137 | 142 | 145 | 153 | 152 | 159 | 155 | 164 | 166 | 77 |
| 76 | | 67 | | 80 | 93 | 102 | 126 | 135 | 141 | 144 | 152 | 151 | 158 | 154 | 162 | 165 | 76 |
| 75 | 59 | 66 | 70 | 79 | 92 | 100 | 124 | 134 | 139 | 143 | 151 | 149 | 156 | 153 | 161 | 164 | 75 |
| 74 | | | 69 | 78 | 91 | 99 | 123 | 133 | 138 | 142 | 149 | 148 | 155 | 152 | 160 | 163 | 74 |
| 73 | | 65 | | 77 | 89 | 97 | 121 | 131 | 137 | 140 | 148 | 147 | 154 | 151 | 158 | 161 | 73 |
| 72 | 58 | 64 | 68 | 76 | 88 | 96 | 119 | 130 | 136 | 139 | 147 | 146 | 152 | 149 | 157 | 160 | 72 |
| 71 | | | 67 | 75 | 87 | 94 | 118 | 129 | 135 | 138 | 145 | 145 | 151 | 148 | 156 | 159 | 71 |
| 70 | 57 | 63 | | 74 | 86 | 93 | 116 | 128 | 133 | 137 | 144 | 143 | 149 | 147 | 154 | 158 | 70 |
| 69 | | 62 | 66 | 73 | 84 | 92 | 114 | 126 | 132 | 136 | 143 | 142 | 148 | 146 | 153 | 157 | 69 |
| 68 | 56 | | 65 | | 83 | 90 | 113 | 125 | 131 | 135 | 142 | 141 | 147 | 144 | 152 | 156 | 68 |
| 67 | | 61 | | 72 | 82 | 89 | 111 | 124 | 130 | 134 | 140 | 140 | 145 | 143 | 150 | 154 | 67 |
| 66 | 55 | 60 | 64 | 71 | 80 | 87 | 109 | 122 | 129 | 132 | 139 | 139 | 144 | 142 | 149 | 153 | 66 |
| 65 | | 59 | | 70 | 79 | 86 | 107 | 121 | 127 | 131 | 138 | 137 | 143 | 141 | 147 | 152 | 65 |
| 64 | 54 | | 63 | 69 | 78 | 84 | 106 | 120 | 126 | 130 | 137 | 136 | 141 | 140 | 146 | 151 | 64 |
| 63 | | 58 | 62 | 68 | 77 | 83 | 104 | 118 | 125 | 129 | 136 | 135 | 140 | 138 | 145 | 150 | 63 |
| 62 | 53 | 57 | | 67 | 75 | 81 | 102 | 117 | 124 | 128 | 134 | 134 | 138 | 137 | 143 | 149 | 62 |
| 61 | | | 61 | 66 | 74 | 80 | 101 | 116 | 123 | 127 | 133 | 133 | 137 | 136 | 142 | 147 | 61 |
| 60 | | 56 | 60 | 65 | 73 | 78 | 99 | 115 | 121 | 126 | 132 | 131 | 136 | 135 | 141 | 146 | 60 |
| 59 | 52 | 55 | | 64 | 72 | 77 | 97 | 113 | 120 | 124 | 130 | 130 | 134 | 133 | 139 | 145 | 59 |
| 58 | | 54 | 59 | | 70 | 75 | 96 | 112 | 119 | 123 | 129 | 129 | 133 | 132 | 138 | 144 | 58 |
| 57 | 51 | | 58 | 63 | 69 | 74 | 94 | 111 | 118 | 122 | 128 | 128 | 131 | 131 | 137 | 143 | 57 |
| 56 | | 53 | | 62 | 68 | 72 | 92 | 109 | 117 | 121 | 127 | 127 | 130 | 130 | 135 | 142 | 56 |
| 55 | 50 | 52 | 57 | 61 | 66 | 71 | 90 | 108 | 115 | 120 | 125 | 125 | 129 | 129 | 134 | 140 | 55 |
| 54 | | | 56 | 60 | 65 | 69 | 89 | 107 | 114 | 119 | 124 | 124 | 127 | 127 | 133 | 139 | 54 |
| 53 | 49 | 51 | | 59 | 64 | 68 | 87 | 106 | 113 | 118 | 123 | 123 | 126 | 126 | 131 | 138 | 53 |
| 52 | | 50 | 55 | 58 | 63 | 66 | 85 | 104 | 112 | 116 | 122 | 122 | 124 | 125 | 130 | 137 | 52 |
| 51 | 48 | 49 | 54 | 57 | 61 | 65 | 84 | 103 | 111 | 115 | 120 | 120 | 123 | 124 | 128 | 136 | 51 |

*6σ/100 right grip strength scales for males by age*

| SCALE SCORE | AGE | | | | | | | | | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
| 50 | | | | 56 | 60 | 63 | 82 | 102 | 109 | 114 | 119 | 119 | 122 | 122 | 127 | 135 | 50 |
| 49 | | | 53 | 55 | 59 | 62 | 80 | 100 | 108 | 113 | 118 | 118 | 120 | 121 | 126 | 133 | 49 |
| 48 | 47 | 47 | | 54 | 57 | 60 | 79 | 99 | 107 | 112 | 117 | 117 | 119 | 120 | 124 | 132 | 48 |
| 47 | | | 52 | | 56 | 59 | 77 | 98 | 106 | 111 | 115 | 116 | 118 | 119 | 123 | 131 | 47 |
| 46 | 46 | 46 | 51 | 53 | 55 | 57 | 75 | 96 | 105 | 110 | 114 | 114 | 116 | 118 | 122 | 130 | 46 |
| 45 | | 45 | | 52 | 54 | 56 | 74 | 95 | 103 | 109 | 113 | 113 | 115 | 116 | 120 | 129 | 45 |
| 44 | 45 | | 50 | 51 | 52 | 54 | 72 | 94 | 102 | 107 | 112 | 112 | 113 | 115 | 119 | 128 | 44 |
| 43 | | 44 | 49 | 50 | 51 | 53 | 70 | 93 | 101 | 106 | 110 | 111 | 112 | 114 | 118 | 127 | 43 |
| 42 | 44 | 43 | | 49 | 50 | 51 | 68 | 91 | 100 | 105 | 109 | 110 | 111 | 113 | 116 | 125 | 42 |
| 41 | | 42 | 48 | 48 | 49 | 50 | 67 | 90 | 99 | 104 | 108 | 108 | 109 | 111 | 115 | 124 | 41 |
| 40 | 43 | | 47 | 47 | 47 | 48 | 65 | 89 | 97 | 103 | 107 | 107 | 108 | 110 | 114 | 123 | 40 |
| 39 | | 41 | | 46 | 46 | 47 | 63 | 87 | 96 | 102 | 105 | 106 | 106 | 109 | 112 | 122 | 39 |
| 38 | 42 | 40 | 46 | 45 | 45 | 45 | 62 | 86 | 95 | 101 | 104 | 105 | 105 | 108 | 111 | 121 | 38 |
| 37 | | | 45 | | 43 | 44 | 60 | 85 | 94 | 99 | 103 | 104 | 104 | 107 | 109 | 120 | 37 |
| 36 | | 39 | | 44 | 42 | 43 | 58 | 84 | 93 | 98 | 102 | 102 | 102 | 105 | 108 | 118 | 36 |
| 35 | 41 | 38 | 44 | 43 | 41 | 41 | 57 | 82 | 91 | 97 | 100 | 101 | 101 | 104 | 107 | 117 | 35 |
| 34 | | 37 | | 42 | 40 | 40 | 55 | 81 | 90 | 96 | 99 | 100 | 99 | 103 | 105 | 116 | 34 |
| 33 | 40 | | 43 | 41 | 38 | 38 | 53 | 80 | 89 | 95 | 98 | 99 | 98 | 102 | 104 | 115 | 33 |
| 32 | | 36 | 42 | 40 | 37 | 37 | 51 | 78 | 88 | 94 | 97 | 98 | 97 | 100 | 103 | 114 | 32 |
| 31 | 39 | 35 | | 39 | 36 | 35 | 50 | 77 | 87 | 93 | 95 | 96 | 95 | 99 | 101 | 113 | 31 |
| 30 | | | 41 | 38 | 34 | 34 | 48 | 76 | 85 | 91 | 94 | 95 | 94 | 98 | 100 | 111 | 30 |
| 29 | 38 | 34 | 40 | 37 | 33 | 32 | 46 | 74 | 84 | 90 | 93 | 94 | 93 | 97 | 99 | 110 | 29 |
| 28 | | 33 | | 36 | 32 | 31 | 45 | 73 | 83 | 89 | 92 | 93 | 91 | 96 | 97 | 109 | 28 |
| 27 | 37 | 32 | 39 | | 31 | 29 | 43 | 72 | 82 | 88 | 90 | 92 | 90 | 94 | 96 | 108 | 27 |
| 26 | | | 38 | 35 | 29 | 28 | 41 | 71 | 81 | 87 | 89 | 90 | 88 | 93 | 95 | 107 | 26 |
| 25 | 36 | 31 | | 34 | 28 | 26 | 40 | 69 | 80 | 86 | 88 | 89 | 87 | 92 | 93 | 106 | 25 |
| 24 | | 30 | 37 | 33 | 27 | 25 | 38 | 68 | 78 | 85 | 86 | 88 | 86 | 91 | 92 | 104 | 24 |
| 23 | | | 36 | 32 | 26 | 23 | 36 | 67 | 77 | 83 | 85 | 87 | 84 | 89 | 90 | 103 | 23 |
| 22 | 35 | 29 | | 31 | 24 | 22 | 34 | 65 | 76 | 82 | 84 | 86 | 83 | 88 | 89 | 102 | 22 |
| 21 | | 28 | 35 | 30 | 23 | 20 | 33 | 64 | 75 | 81 | 83 | 84 | 81 | 87 | 88 | 101 | 21 |
| 20 | 34 | | 34 | 29 | 22 | 19 | 31 | 63 | 74 | 80 | 81 | 83 | 80 | 86 | 86 | 100 | 20 |
| 19 | | 27 | | 28 | 20 | 17 | 29 | 62 | 72 | 79 | 80 | 82 | 79 | 85 | 85 | 99 | 19 |
| 18 | 33 | 26 | 33 | 27 | 19 | 16 | 28 | 60 | 71 | 78 | 79 | 81 | 77 | 83 | 84 | 97 | 18 |
| 17 | | 25 | | | 18 | 14 | 26 | 59 | 70 | 77 | 78 | 80 | 76 | 82 | 82 | 96 | 17 |
| 16 | 32 | | 32 | 26 | 17 | 13 | 24 | 58 | 69 | 76 | 76 | 78 | 74 | 81 | 81 | 95 | 16 |
| 15 | | 24 | 31 | 25 | 15 | 11 | 23 | 56 | 68 | 74 | 75 | 77 | 73 | 80 | 80 | 94 | 15 |
| 14 | 31 | 23 | | 24 | 14 | 10 | 21 | 55 | 66 | 73 | 74 | 76 | 72 | 78 | 78 | 93 | 14 |
| 13 | | | 30 | 23 | 13 | 8 | 19 | 54 | 65 | 72 | 73 | 75 | 70 | 77 | 77 | 92 | 13 |
| 12 | | 22 | 29 | 22 | 11 | 7 | 17 | 53 | 64 | 71 | 71 | 74 | 69 | 76 | 76 | 91 | 12 |
| 11 | 30 | 21 | | 21 | 10 | 5 | 16 | 51 | 63 | 70 | 70 | 72 | 68 | 75 | 74 | 89 | 11 |
| 10 | | 20 | 28 | 20 | 9 | 4 | 14 | 50 | 62 | 69 | 69 | 71 | 66 | 73 | 73 | 88 | 10 |
| 9 | 29 | | 27 | 19 | 8 | 2 | 12 | 49 | 60 | 68 | 68 | 70 | 65 | 72 | 71 | 87 | 9 |
| 8 | | 19 | | 18 | 6 | 1 | 11 | 47 | 59 | 66 | 66 | 69 | 63 | 71 | 70 | 86 | 8 |
| 7 | 28 | 18 | 26 | 17 | 5 | | 9 | 46 | 58 | 65 | 65 | 68 | 62 | 70 | 69 | 85 | 7 |
| 6 | | | 25 | | 4 | | 7 | 45 | 57 | 64 | 64 | 66 | 61 | 69 | 67 | 84 | 6 |
| 5 | 27 | 17 | | 16 | 3 | | 6 | 43 | 56 | 63 | 63 | 65 | 60 | 67 | 66 | 82 | 5 |
| 4 | | 16 | 24 | 15 | 1 | | 4 | 42 | 54 | 62 | 61 | 64 | 58 | 66 | 65 | 81 | 4 |
| 3 | 26 | | | 14 | | | 2 | 41 | 53 | 61 | 60 | 63 | 56 | 65 | 63 | 80 | 3 |
| 2 | | 15 | 23 | 13 | | | 1 | 40 | 52 | 60 | 59 | 62 | 55 | 64 | 62 | 79 | 2 |
| 1 | 25 | 14 | 22 | 12 | | | | 38 | 51 | 58 | 58 | 60 | 54 | 62 | 61 | 78 | 1 |

LEFT GRIP STRENGTH OF MALES BY WEIGHT

Left hand grip strength generally increases with an increase in weight. There is little progression in left grip strength up to the interval 90–99 pounds. A marked acceleration in progression occurs from 90–130 pounds. Acceleration is slower, but steady, from 130 to 190 pounds, after which grip strengths level off. Occasional irregularities show up from 69–130 pounds. Variability is slight up through the 90–99 pounds interval. It increases from 100 to 120–129 pounds where the variability is greatest. Wide and almost equal variability occurs along with the progression range from 130 pounds through 210 and up. Males weighing less than 70 pounds have the smallest mean grip strength. 41 pounds, and those weighing 210 pounds and up have the greatest mean grip strength, 126 pounds. Mean grip strength and variability for the left hand in relation to weight is much more regular than for either hand with age. Left grip strength in relation to weight is consistently lower than right grip strength in this study, and is more regular in progression and variability.

RIGHT GRIP STRENGTH OF MALES BY WEIGHT

There is a general increase in mean right grip strength with increase in weight. Mean grip strength progression is steady with the exception of these three irregularities at 100, 110, 120, and a drop at the 200 pounds interval. These irregularities may have been caused by the difference in sample size. Variability is small up to 90 pounds and wider from 90 to 210 pounds and up. The slight irregularities in variability might well be attributed to differences in the number of cases. Males weighing less than 70 pounds have the smallest mean grip strength, 45 pounds, and those men weighing over 210 pounds and up have the greatest mean grip strength, 143 pounds. The right grip strength in relation to weight shows more irregularity in progression and variability than does the left hand grip strength. The right mean grip strength of males in relation to weight is from 3–13 pounds greater than left hand mean grip strength for every weight group.

LEFT GRIP STRENGTH OF MALES BY CLASSIFICATION INDEX I

Left hand grip strength tends to increase with an increase in Classification Index I. There is a plateau with but slight progression in grip strength from up to 594–700. From 700–980 and up there is marked and regular increase in mean grip strength, with the greatest acceleration from 700 to 875. The left grip strength seems to be approximately equally variable from Classification Index of 630 and up. The least variable is the Classification Index interval of up to 594. This interval has the least number of cases. The men with the highest Classification Index had the greatest mean grip strength, 127 pounds, and the boys with the Classification Index up to 700 had the lowest mean grip strength, 38 pounds. The left grip strength progresses more consistently with Classification Index, which includes age, height, and weight, than it does with either age or weight. Left hand grip

*6σ/100 left grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | Up to 69 | 70–9 | 80–9 | 90–9 | 100–9 | 110–9 | 120–9 | 130–9 | |
| 100 | 73 | 85 | 96 | 107 | 123 | 138 | 156 | 158 | 100 |
| 99 | | 84 | 95 | 106 | 121 | 136 | 155 | 157 | 99 |
| 98 | 72 | | 94 | 105 | 120 | 135 | 153 | 155 | 98 |
| 97 | 71 | 83 | 93 | 104 | 119 | 133 | 152 | 154 | 97 |
| 96 | | 82 | 92 | 102 | 117 | 132 | 150 | 153 | 96 |
| 95 | 70 | 81 | 91 | 101 | 116 | 131 | 148 | 151 | 95 |
| 94 | 69 | | 90 | 100 | 115 | 129 | 147 | 150 | 94 |
| 93 | | 80 | 89 | 99 | 114 | 128 | 145 | 149 | 93 |
| 92 | 68 | 79 | 88 | 98 | 112 | 126 | 144 | 147 | 92 |
| 91 | 67 | 78 | 87 | 96 | 111 | 125 | 142 | 146 | 91 |
| 90 | | 77 | 86 | 95 | 110 | 123 | 141 | 145 | 90 |
| 89 | 66 | | 85 | 94 | 108 | 122 | 139 | 143 | 89 |
| 88 | | 76 | 84 | 93 | 107 | 120 | 138 | 142 | 88 |
| 87 | 65 | 75 | 83 | 92 | 106 | 119 | 136 | 141 | 87 |
| 86 | 64 | 74 | 82 | 90 | 104 | 117 | 134 | 139 | 86 |
| 85 | | | 81 | 89 | 103 | 116 | 133 | 138 | 85 |
| 84 | 63 | 73 | 80 | 88 | 102 | 114 | 131 | 137 | 84 |
| 83 | 62 | 72 | 79 | 87 | 101 | 113 | 130 | 135 | 83 |
| 82 | | 71 | 78 | 86 | 99 | 111 | 128 | 134 | 82 |
| 81 | 61 | | 77 | 84 | 98 | 110 | 127 | 133 | 81 |
| 80 | 60 | 70 | 76 | 83 | 97 | 108 | 125 | 131 | 80 |
| 79 | | 69 | 75 | 82 | 95 | 107 | 123 | 130 | 79 |
| 78 | 59 | 68 | 74 | 81 | 94 | 105 | 122 | 129 | 78 |
| 77 | | | 73 | 80 | 93 | 104 | 120 | 127 | 77 |
| 76 | 58 | 67 | 72 | 78 | 91 | 102 | 119 | 126 | 76 |
| 75 | 57 | 66 | 71 | 77 | 90 | 101 | 117 | 125 | 75 |
| 74 | | 65 | 70 | 76 | 89 | 99 | 116 | 123 | 74 |
| 73 | 56 | | 69 | 75 | 88 | 98 | 114 | 122 | 73 |
| 72 | 55 | 64 | 68 | 74 | 86 | 96 | 113 | 121 | 72 |
| 71 | | 63 | 67 | 72 | 85 | 95 | 111 | 119 | 71 |
| 70 | 54 | 62 | 66 | 71 | 84 | 93 | 109 | 118 | 70 |
| 69 | 53 | | 65 | 70 | 82 | 92 | 108 | 117 | 69 |
| 68 | | 61 | 64 | 69 | 81 | 90 | 106 | 115 | 68 |
| 67 | 52 | 60 | 63 | 68 | 80 | 89 | 105 | 114 | 67 |
| 66 | 51 | 59 | 62 | 66 | 78 | 87 | 103 | 113 | 66 |
| 65 | | | 61 | 65 | 77 | 86 | 102 | 111 | 65 |
| 64 | 50 | 58 | 60 | 64 | 76 | 84 | 100 | 110 | 64 |
| 63 | | 57 | 59 | 63 | 75 | 83 | 98 | 109 | 63 |
| 62 | 49 | 56 | 58 | 62 | 73 | 81 | 97 | 107 | 62 |
| 61 | 48 | | 57 | 60 | 72 | 80 | 95 | 106 | 61 |
| 60 | | 55 | 56 | 59 | 71 | 78 | 94 | 105 | 60 |
| 59 | 47 | 54 | 55 | 58 | 69 | 77 | 92 | 103 | 59 |
| 58 | 46 | 53 | 54 | 57 | 68 | 75 | 90 | 102 | 58 |
| 57 | | | 53 | 56 | 67 | 74 | 89 | 101 | 57 |
| 56 | 45 | 52 | 52 | 54 | 65 | 72 | 88 | 99 | 56 |
| 55 | 44 | 51 | 51 | 53 | 64 | 71 | 86 | 98 | 55 |
| 54 | | 50 | 50 | 52 | 63 | 69 | 84 | 97 | 54 |
| 53 | 43 | | 49 | 51 | 61 | 68 | 83 | 95 | 53 |
| 52 | | 49 | 48 | 50 | 60 | 66 | 81 | 94 | 52 |
| 51 | 42 | 48 | 47 | 48 | 59 | 65 | 80 | 93 | 51 |

*6σ/100 left grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | Up to 69 | 70–9 | 80–9 | 90–9 | 100–9 | 110–9 | 120–9 | 130–9 | |
| 50 | 41 | 47 | 46 | 47 | 58 | 63 | 78 | 91 | 50 |
| 49 | | 46 | 45 | 46 | 56 | 62 | 77 | 90 | 49 |
| 48 | 40 | | | 45 | 55 | 60 | 75 | 89 | 48 |
| 47 | 39 | 45 | 44 | 44 | 54 | 59 | 73 | 87 | 47 |
| 46 | | 44 | 43 | 42 | 52 | 57 | 72 | 86 | 46 |
| 45 | 38 | 43 | 42 | 41 | 51 | 56 | 70 | 85 | 45 |
| 44 | 37 | | 41 | 40 | 50 | 54 | 69 | 83 | 44 |
| 43 | | 42 | 40 | 39 | 48 | 53 | 67 | 82 | 43 |
| 42 | 36 | 41 | 39 | 38 | 47 | 51 | 66 | 81 | 42 |
| 41 | | 40 | 38 | 36 | 46 | 50 | 64 | 79 | 41 |
| 40 | 35 | | 37 | 35 | 45 | 49 | 63 | 78 | 40 |
| 39 | 34 | 39 | 36 | 34 | 43 | 47 | 61 | 77 | 39 |
| 38 | | 38 | 35 | 33 | 42 | 46 | 59 | 75 | 38 |
| 37 | 33 | 37 | 34 | 32 | 41 | 44 | 58 | 74 | 37 |
| 36 | 32 | | 33 | 30 | 39 | 43 | 56 | 73 | 36 |
| 35 | | 36 | 32 | 29 | 38 | 41 | 55 | 71 | 35 |
| 34 | 31 | 35 | 31 | 28 | 37 | 40 | 53 | 70 | 34 |
| 33 | 30 | 34 | 30 | 27 | 35 | 38 | 52 | 69 | 33 |
| 32 | | | 29 | 26 | 34 | 37 | 50 | 67 | 32 |
| 31 | 29 | 33 | 28 | 24 | 33 | 35 | 48 | 66 | 31 |
| 30 | 28 | 32 | 27 | 23 | 32 | 34 | 47 | 65 | 30 |
| 29 | | 31 | 26 | 22 | 30 | 32 | 45 | 63 | 29 |
| 28 | 27 | | 25 | 21 | 29 | 31 | 44 | 62 | 28 |
| 27 | | 30 | 24 | 20 | 28 | 29 | 42 | 61 | 27 |
| 26 | 26 | 29 | 23 | 18 | 26 | 28 | 41 | 59 | 26 |
| 25 | 25 | 28 | 22 | 17 | 25 | 26 | 39 | 58 | 25 |
| 24 | | | 21 | 16 | 24 | 25 | 38 | 57 | 24 |
| 23 | 24 | 27 | 20 | 15 | 22 | 23 | 36 | 55 | 23 |
| 22 | 23 | 26 | 19 | 14 | 21 | 22 | 34 | 54 | 22 |
| 21 | | 25 | 18 | 12 | 20 | 20 | 33 | 53 | 21 |
| 20 | 22 | | 17 | 11 | 19 | 19 | 31 | 51 | 20 |
| 19 | 21 | 24 | 16 | 10 | 17 | 17 | 30 | 50 | 19 |
| 18 | | 23 | 15 | 9 | 16 | 16 | 28 | 49 | 18 |
| 17 | 20 | 22 | 14 | 8 | 15 | 14 | 27 | 47 | 17 |
| 16 | | | 13 | 6 | 13 | 13 | 25 | 46 | 16 |
| 15 | 19 | 21 | 12 | 5 | 12 | 11 | 23 | 45 | 15 |
| 14 | 18 | 20 | 11 | 4 | 11 | 10 | 22 | 43 | 14 |
| 13 | | 19 | 10 | 3 | 9 | 8 | 20 | 42 | 13 |
| 12 | 17 | | 9 | 2 | 8 | 7 | 19 | 41 | 12 |
| 11 | 16 | 18 | 8 | | 7 | 5 | 17 | 39 | 11 |
| 10 | | 17 | 7 | | 5 | 4 | 16 | 38 | 10 |
| 9 | 15 | 16 | 6 | | 4 | 2 | 14 | 37 | 9 |
| 8 | 14 | 15 | 5 | | 3 | 1 | 13 | 35 | 8 |
| 7 | | | 4 | | 2 | | 11 | 34 | 7 |
| 6 | 13 | 14 | 3 | | | | 9 | 33 | 6 |
| 5 | | 13 | 2 | | | | 8 | 31 | 5 |
| 4 | 12 | 12 | 1 | | | | 6 | 30 | 4 |
| 3 | 11 | | | | | | 5 | 29 | 3 |
| 2 | | 11 | | | | | 3 | 27 | 2 |
| 1 | 10 | 10 | | | | | 2 | 26 | 1 |

*6σ/100 left grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | 140–9 | 150–9 | 160–9 | 170–9 | 180–9 | 190–9 | 200–9 | 210 up | |
| 100 | 158 | 164 | 174 | 169 | 182 | 179 | 189 | 180 | 100 |
| 99 | 157 | 163 | 173 | 168 | 181 | 178 | 188 | 179 | 99 |
| 98 | 155 | 162 | 172 | 167 | 170 | 177 | 186 | 178 | 98 |
| 97 | 154 | 160 | 170 | 166 | 178 | 176 | 185 | 177 | 97 |
| 96 | 153 | 159 | 169 | 164 | 177 | 174 | 184 | 176 | 96 |
| 95 | 152 | 158 | 168 | 163 | 176 | 173 | 183 | 175 | 95 |
| 94 | 151 | 157 | 167 | 162 | 174 | 172 | 181 | 174 | 94 |
| 93 | 149 | 155 | 165 | 161 | 173 | 171 | 180 | 173 | 93 |
| 92 | 148 | 154 | 164 | 160 | 172 | 170 | 179 | 171 | 92 |
| 91 | 147 | 153 | 163 | 159 | 171 | 169 | 178 | 170 | 91 |
| 90 | 146 | 152 | 161 | 158 | 169 | 168 | 176 | 169 | 90 |
| 89 | 145 | 150 | 160 | 157 | 168 | 167 | 175 | 168 | 89 |
| 88 | 144 | 149 | 159 | 155 | 167 | 166 | 174 | 167 | 88 |
| 87 | 142 | 148 | 157 | 154 | 165 | 165 | 173 | 166 | 87 |
| 86 | 141 | 147 | 156 | 153 | 164 | 163 | 171 | 165 | 86 |
| 85 | 140 | 146 | 155 | 152 | 163 | 162 | 170 | 164 | 85 |
| 84 | 139 | 144 | 153 | 151 | 162 | 161 | 169 | 163 | 84 |
| 83 | 138 | 143 | 152 | 150 | 150 | 160 | 167 | 162 | 83 |
| 82 | 136 | 142 | 151 | 149 | 159 | 159 | 166 | 161 | 82 |
| 81 | 135 | 141 | 149 | 148 | 158 | 158 | 165 | 160 | 81 |
| 80 | 134 | 139 | 148 | 146 | 156 | 157 | 164 | 159 | 80 |
| 79 | 133 | 138 | 147 | 145 | 155 | 156 | 162 | 157 | 79 |
| 78 | 132 | 137 | 145 | 144 | 154 | 155 | 161 | 156 | 78 |
| 77 | 130 | 136 | 144 | 143 | 152 | 154 | 160 | 155 | 77 |
| 76 | 129 | 134 | 143 | 142 | 151 | 152 | 159 | 154 | 76 |
| 75 | 128 | 133 | 141 | 141 | 150 | 151 | 157 | 153 | 75 |
| 74 | 127 | 132 | 140 | 140 | 149 | 150 | 156 | 152 | 74 |
| 73 | 126 | 131 | 139 | 139 | 147 | 149 | 155 | 151 | 73 |
| 72 | 125 | 129 | 137 | 137 | 146 | 148 | 153 | 150 | 72 |
| 71 | 123 | 128 | 136 | 136 | 145 | 147 | 152 | 149 | 71 |
| 70 | 122 | 127 | 135 | 135 | 143 | 146 | 151 | 148 | 70 |
| 69 | 121 | 126 | 134 | 134 | 142 | 145 | 150 | 147 | 69 |
| 68 | 120 | 124 | 132 | 133 | 141 | 144 | 148 | 146 | 68 |
| 67 | 119 | 123 | 131 | 132 | 140 | 142 | 147 | 145 | 67 |
| 66 | 117 | 122 | 130 | 131 | 138 | 141 | 146 | 143 | 66 |
| 65 | 116 | 121 | 128 | 130 | 137 | 140 | 145 | 142 | 65 |
| 64 | 115 | 119 | 127 | 128 | 136 | 139 | 143 | 141 | 64 |
| 63 | 114 | 118 | 126 | 127 | 134 | 138 | 142 | 140 | 63 |
| 62 | 113 | 117 | 124 | 126 | 133 | 137 | 141 | 139 | 62 |
| 61 | 111 | 116 | 123 | 125 | 132 | 136 | 140 | 138 | 61 |
| 60 | 110 | 114 | 122 | 124 | 131 | 135 | 138 | 137 | 60 |
| 59 | 109 | 113 | 120 | 123 | 129 | 134 | 137 | 136 | 59 |
| 58 | 108 | 112 | 119 | 122 | 128 | 133 | 136 | 135 | 58 |
| 57 | 107 | 111 | 118 | 120 | 127 | 131 | 134 | 134 | 57 |
| 56 | 106 | 109 | 116 | 119 | 125 | 130 | 133 | 133 | 56 |
| 55 | 104 | 108 | 115 | 118 | 124 | 129 | 132 | 132 | 55 |
| 54 | 103 | 107 | 114 | 117 | 123 | 128 | 131 | 131 | 54 |
| 53 | 102 | 106 | 112 | 116 | 121 | 127 | 129 | 129 | 53 |
| 52 | 101 | 104 | 111 | 115 | 120 | 126 | 128 | 128 | 52 |
| 51 | 100 | 103 | 110 | 114 | 119 | 125 | 127 | 127 | 51 |

*6σ/100 left grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | 140–9 | 150–9 | 160–9 | 170–9 | 180–9 | 190–9 | 200–9 | 210 up | |
| 50 | 98 | 102 | 108 | 113 | 118 | 124 | 126 | 126 | 50 |
| 49 | 97 | 101 | 107 | 111 | 116 | 123 | 124 | 125 | 49 |
| 48 | 96 | 99 | 106 | 110 | 115 | 122 | 123 | 124 | 48 |
| 47 | 95 | 98 | 104 | 109 | 114 | 120 | 122 | 123 | 47 |
| 46 | 94 | 97 | 103 | 108 | 112 | 119 | 120 | 122 | 46 |
| 45 | 92 | 96 | 102 | 107 | 111 | 118 | 119 | 121 | 45 |
| 44 | 91 | 94 | 101 | 106 | 110 | 117 | 118 | 120 | 44 |
| 43 | 90 | 93 | 99 | 105 | 109 | 116 | 117 | 119 | 43 |
| 42 | 89 | 92 | 98 | 104 | 107 | 115 | 115 | 118 | 42 |
| 41 | 88 | 91 | 97 | 102 | 106 | 114 | 114 | 117 | 41 |
| 40 | 87 | 89 | 95 | 101 | 105 | 113 | 113 | 115 | 40 |
| 39 | 85 | 88 | 94 | 100 | 103 | 112 | 112 | 114 | 39 |
| 38 | 84 | 87 | 93 | 99 | 102 | 111 | 110 | 113 | 38 |
| 37 | 83 | 86 | 91 | 98 | 101 | 109 | 109 | 112 | 37 |
| 36 | 82 | 85 | 90 | 97 | 99 | 108 | 108 | 111 | 36 |
| 35 | 81 | 83 | 89 | 96 | 98 | 107 | 107 | 110 | 35 |
| 34 | 79 | 82 | 87 | 95 | 97 | 106 | 105 | 109 | 34 |
| 33 | 78 | 81 | 86 | 93 | 96 | 105 | 104 | 108 | 33 |
| 32 | 77 | 80 | 85 | 92 | 94 | 104 | 103 | 107 | 32 |
| 31 | 76 | 78 | 83 | 91 | 93 | 103 | 101 | 106 | 31 |
| 30 | 75 | 77 | 82 | 90 | 92 | 102 | 100 | 105 | 30 |
| 29 | 73 | 76 | 81 | 89 | 90 | 101 | 99 | 104 | 29 |
| 28 | 72 | 75 | 79 | 88 | 89 | 100 | 98 | 103 | 28 |
| 27 | 71 | 73 | 78 | 87 | 88 | 98 | 96 | 101 | 27 |
| 26 | 70 | 72 | 77 | 86 | 87 | 97 | 95 | 100 | 26 |
| 25 | 69 | 71 | 75 | 84 | 85 | 96 | 94 | 99 | 25 |
| 24 | 68 | 79 | 74 | 73 | 84 | 95 | 93 | 98 | 24 |
| 23 | 66 | 68 | 73 | 82 | 83 | 94 | 91 | 97 | 23 |
| 22 | 65 | 67 | 71 | 81 | 81 | 93 | 90 | 96 | 22 |
| 21 | 64 | 66 | 70 | 80 | 80 | 92 | 89 | 95 | 21 |
| 20 | 63 | 65 | 69 | 79 | 79 | 91 | 88 | 94 | 20 |
| 19 | 62 | 63 | 68 | 78 | 78 | 90 | 86 | 93 | 19 |
| 18 | 60 | 62 | 66 | 76 | 76 | 89 | 85 | 92 | 18 |
| 17 | 59 | 61 | 65 | 75 | 75 | 87 | 84 | 91 | 17 |
| 16 | 58 | 60 | 64 | 74 | 74 | 86 | 82 | 90 | 16 |
| 15 | 57 | 58 | 62 | 73 | 72 | 85 | 81 | 88 | 15 |
| 14 | 56 | 57 | 61 | 72 | 71 | 84 | 80 | 87 | 14 |
| 13 | 54 | 56 | 60 | 71 | 70 | 83 | 79 | 86 | 13 |
| 12 | 53 | 55 | 58 | 70 | 68 | 82 | 77 | 85 | 12 |
| 11 | 52 | 53 | 57 | 69 | 67 | 81 | 76 | 84 | 11 |
| 10 | 51 | 52 | 56 | 67 | 66 | 80 | 75 | 83 | 10 |
| 9 | 50 | 51 | 54 | 66 | 65 | 79 | 74 | 82 | 9 |
| 8 | 48 | 50 | 53 | 65 | 63 | 78 | 72 | 81 | 8 |
| 7 | 47 | 48 | 52 | 64 | 62 | 76 | 71 | 80 | 7 |
| 6 | 46 | 47 | 50 | 63 | 61 | 75 | 70 | 79 | 6 |
| 5 | 45 | 46 | 49 | 62 | 59 | 74 | 68 | 78 | 5 |
| 4 | 44 | 45 | 48 | 61 | 58 | 73 | 67 | 77 | 4 |
| 3 | 43 | 43 | 46 | 60 | 57 | 72 | 66 | 76 | 3 |
| 2 | 41 | 42 | 45 | 58 | 56 | 71 | 65 | 74 | 2 |
| 1 | 40 | 41 | 44 | 57 | 54 | 70 | 63 | 73 | 1 |

*6σ/100 right grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | Up to 69 | 70–9 | 80–9 | 90–9 | 100–9 | 110–9 | 120–9 | 130–9 | |
| 100 | 82 | 87 | 100 | 120 | 132 | 133 | 167 | 168 | 100 |
| 99 | | 86 | 99 | 119 | 131 | 132 | 165 | 167 | 99 |
| 98 | 81 | | 98 | 117 | 130 | 131 | 164 | 165 | 98 |
| 97 | 80 | 85 | 97 | 116 | 128 | 129 | 162 | 164 | 97 |
| 96 | 79 | 84 | 96 | 115 | 127 | 128 | 160 | 163 | 96 |
| 95 | | | 95 | 114 | 126 | 127 | 159 | 161 | 95 |
| 94 | 78 | 83 | 94 | 112 | 124 | 125 | 157 | 160 | 94 |
| 93 | 77 | 82 | 93 | 111 | 123 | 124 | 156 | 158 | 93 |
| 92 | | | 92 | 110 | 122 | 123 | 154 | 157 | 92 |
| 91 | 76 | 81 | 91 | 108 | 121 | 121 | 152 | 156 | 91 |
| 90 | 75 | 80 | | 107 | 119 | 120 | 151 | 154 | 90 |
| 89 | 74 | | 90 | 106 | 118 | 119 | 149 | 153 | 89 |
| 88 | | 79 | 89 | 105 | 117 | 117 | 148 | 152 | 88 |
| 87 | 73 | 78 | 88 | 103 | 115 | 116 | 146 | 150 | 87 |
| 86 | 72 | | 87 | 102 | 114 | 115 | 145 | 149 | 86 |
| 85 | 71 | 77 | 86 | 101 | 113 | 113 | 143 | 147 | 85 |
| 84 | | 76 | 85 | 99 | 111 | 112 | 141 | 146 | 84 |
| 83 | 70 | | 84 | 98 | 110 | 111 | 140 | 145 | 83 |
| 82 | 69 | 75 | 83 | 97 | 109 | 109 | 138 | 143 | 82 |
| 81 | 68 | 74 | 82 | 95 | 107 | 108 | 137 | 142 | 81 |
| 80 | | 73 | 81 | 94 | 106 | 107 | 135 | 141 | 80 |
| 79 | 67 | | 80 | 93 | 105 | 105 | 133 | 139 | 79 |
| 78 | 66 | 72 | 79 | 92 | 104 | 104 | 132 | 138 | 78 |
| 77 | 65 | 71 | 78 | 90 | 102 | 103 | 130 | 136 | 77 |
| 76 | | | 77 | 89 | 101 | 101 | 129 | 135 | 76 |
| 75 | 64 | 70 | 76 | 88 | 100 | 100 | 127 | 134 | 75 |
| 74 | 63 | 69 | 75 | 86 | 98 | 99 | 126 | 132 | 74 |
| 73 | 62 | | | 85 | 97 | 97 | 124 | 131 | 73 |
| 72 | | 68 | 74 | 84 | 96 | 96 | 122 | 130 | 72 |
| 71 | 61 | 67 | 73 | 82 | 94 | 95 | 121 | 128 | 71 |
| 70 | 60 | | 72 | 81 | 93 | 93 | 119 | 127 | 70 |
| 69 | 59 | 66 | 71 | 80 | 92 | 92 | 118 | 125 | 69 |
| 68 | | 65 | 70 | 79 | 90 | 91 | 116 | 124 | 68 |
| 67 | 58 | | 69 | 77 | 89 | 89 | 114 | 123 | 67 |
| 66 | 57 | 64 | 68 | 76 | 88 | 88 | 113 | 121 | 66 |
| 65 | 56 | 63 | 67 | 75 | 86 | 87 | 111 | 120 | 65 |
| 64 | | | 66 | 73 | 85 | 85 | 110 | 119 | 64 |
| 63 | 55 | 62 | 65 | 72 | 84 | 84 | 108 | 117 | 63 |
| 62 | 54 | 61 | 64 | 71 | 83 | 83 | 107 | 116 | 62 |
| 61 | | | 63 | 70 | 81 | 81 | 105 | 114 | 61 |
| 60 | 53 | 60 | 62 | 68 | 80 | 80 | 103 | 113 | 60 |
| 59 | 52 | 59 | 61 | 67 | 79 | 79 | 102 | 112 | 59 |
| 58 | 51 | | 60 | 66 | 77 | 77 | 100 | 110 | 58 |
| 57 | | 58 | | 64 | 76 | 76 | 99 | 109 | 57 |
| 56 | 50 | 57 | 59 | 63 | 75 | 75 | 97 | 108 | 56 |
| 55 | 49 | | 58 | 62 | 73 | 73 | 95 | 106 | 55 |
| 54 | 48 | 56 | 57 | 60 | 72 | 71 | 94 | 105 | 54 |
| 53 | | 55 | 56 | 59 | 71 | 70 | 92 | 103 | 53 |
| 52 | 47 | | 55 | 58 | 69 | 69 | 91 | 102 | 52 |
| 51 | 46 | 54 | 54 | 57 | 68 | 68 | 89 | 101 | 51 |

*6σ/100 right grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | Up to 69 | 70–9 | 80–9 | 90–9 | 100–9 | 110–9 | 120–9 | 130–9 | |
| 50 | 45 | 53 | 53 | 55 | 67 | 66 | 88 | 99 | 50 |
| 49 | | 52 | 52 | 54 | 65 | 65 | 86 | 98 | 49 |
| 48 | 44 | | 51 | 53 | 64 | 64 | 84 | 97 | 48 |
| 47 | 43 | 51 | 50 | 52 | 63 | 62 | 83 | 95 | 47 |
| 46 | 42 | 50 | 49 | 50 | 62 | 61 | 81 | 94 | 46 |
| 45 | | | 48 | 49 | 60 | 60 | 80 | 92 | 45 |
| 44 | 41 | 49 | 47 | 47 | 59 | 58 | 78 | 91 | 44 |
| 43 | 40 | 48 | 46 | 46 | 58 | 57 | 76 | 90 | 43 |
| 42 | 39 | | 45 | 45 | 56 | 56 | 75 | 88 | 42 |
| 41 | | 47 | | 44 | 55 | 54 | 73 | 87 | 41 |
| 40 | 38 | 46 | 44 | 43 | 54 | 53 | 72 | 85 | 40 |
| 39 | 37 | | 43 | 41 | 52 | 52 | 70 | 84 | 39 |
| 38 | 36 | 45 | 42 | 40 | 51 | 50 | 68 | 83 | 38 |
| 37 | | 44 | 41 | 39 | 50 | 49 | 67 | 81 | 37 |
| 36 | 35 | | 40 | 37 | 48 | 48 | 65 | 80 | 36 |
| 35 | 34 | 43 | 39 | 36 | 47 | 46 | 64 | 79 | 35 |
| 34 | 33 | 42 | 38 | 35 | 46 | 45 | 62 | 77 | 34 |
| 33 | | | 37 | 33 | 45 | 44 | 61 | 76 | 33 |
| 32 | 32 | 41 | 36 | 32 | 43 | 42 | 59 | 74 | 32 |
| 31 | 31 | 40 | 35 | 31 | 42 | 41 | 57 | 73 | 31 |
| 30 | | 39 | 34 | 30 | 41 | 40 | 56 | 72 | 30 |
| 29 | 30 | | 33 | 28 | 39 | 38 | 54 | 70 | 29 |
| 28 | 29 | 38 | 32 | 27 | 38 | 37 | 53 | 69 | 28 |
| 27 | 28 | | 31 | 26 | 37 | 36 | 51 | 68 | 27 |
| 26 | | 37 | 30 | 24 | 35 | 34 | 49 | 66 | 26 |
| 25 | 27 | 36 | 29 | 23 | 34 | 33 | 48 | 65 | 25 |
| 24 | 26 | | | 22 | 33 | 32 | 46 | 63 | 24 |
| 23 | 25 | 35 | 28 | 20 | 31 | 30 | 45 | 62 | 23 |
| 22 | | 34 | 27 | 19 | 30 | 29 | 43 | 61 | 22 |
| 21 | 24 | 33 | 26 | 18 | 29 | 28 | 42 | 59 | 21 |
| 20 | 23 | | 25 | 17 | 27 | 26 | 40 | 58 | 20 |
| 19 | 22 | 32 | 24 | 15 | 26 | 25 | 38 | 57 | 19 |
| 18 | | 31 | 23 | 14 | 25 | 24 | 37 | 55 | 18 |
| 17 | 21 | | 22 | 13 | 24 | 22 | 35 | 54 | 17 |
| 16 | 20 | 30 | 21 | 11 | 22 | 21 | 34 | 52 | 16 |
| 15 | 19 | 29 | 20 | 10 | 21 | 20 | 32 | 51 | 15 |
| 14 | | | 19 | 9 | 20 | 18 | 30 | 50 | 14 |
| 13 | 18 | 28 | 18 | 8 | 18 | 17 | 29 | 48 | 13 |
| 12 | 17 | 27 | 17 | 6 | 17 | 16 | 27 | 47 | 12 |
| 11 | 16 | | 16 | 5 | 16 | 14 | 26 | 46 | 11 |
| 10 | | 26 | 15 | 4 | 14 | 13 | 24 | 44 | 10 |
| 9 | 15 | 25 | 14 | 2 | 13 | 12 | 23 | 43 | 9 |
| 8 | 14 | | | 1 | 12 | 10 | 21 | 41 | 8 |
| 7 | 13 | 24 | 13 | | 10 | 9 | 19 | 40 | 7 |
| 6 | | 23 | 12 | | 9 | 8 | 18 | 39 | 6 |
| 5 | 12 | | 11 | | 8 | 6 | 16 | 37 | 5 |
| 4 | 11 | 22 | 10 | | 7 | 5 | 15 | 36 | 4 |
| 3 | 10 | 21 | 9 | | 5 | 4 | 13 | 35 | 3 |
| 2 | | | 8 | | 4 | 2 | 11 | 33 | 2 |
| 1 | 9 | 20 | 7 | | 3 | 1 | 10 | 32 | 1 |

*6σ/100 right grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | 140–9 | 150–9 | 160–9 | 170–9 | 180–9 | 190–9 | 200–9 | 210 up | |
| 100 | 165 | 177 | 187 | 183 | 199 | 187 | 188 | 200 | 100 |
| 99 | 164 | 176 | 185 | 182 | 197 | 186 | 187 | 199 | 99 |
| 98 | 163 | 174 | 184 | 181 | 196 | 185 | 196 | 198 | 98 |
| 97 | 162 | 173 | 182 | 180 | 194 | 184 | 185 | 197 | 97 |
| 96 | 160 | 172 | 181 | 178 | 193 | 183 | 184 | 196 | 96 |
| 95 | 159 | 170 | 180 | 177 | 192 | 182 | 183 | 194 | 95 |
| 94 | 158 | 169 | 178 | 176 | 190 | 181 | 182 | 193 | 94 |
| 93 | 157 | 168 | 177 | 175 | 189 | 180 | 181 | 192 | 93 |
| 92 | 156 | 167 | 176 | 174 | 187 | 179 | 179 | 191 | 92 |
| 91 | 155 | 165 | 174 | 173 | 186 | 178 | 178 | 190 | 91 |
| 90 | 153 | 164 | 173 | 171 | 184 | 177 | 177 | 189 | 90 |
| 89 | 152 | 163 | 172 | 170 | 183 | 176 | 176 | 188 | 89 |
| 88 | 151 | 161 | 170 | 169 | 182 | 175 | 175 | 186 | 88 |
| 87 | 150 | 160 | 169 | 168 | 180 | 174 | 174 | 185 | 87 |
| 86 | 149 | 159 | 168 | 166 | 179 | 173 | 173 | 184 | 86 |
| 85 | 148 | 158 | 166 | 165 | 177 | 172 | 172 | 183 | 85 |
| 84 | 146 | 156 | 165 | 164 | 176 | 171 | 171 | 182 | 84 |
| 83 | 145 | 155 | 164 | 163 | 174 | 170 | 170 | 181 | 83 |
| 82 | 144 | 154 | 162 | 162 | 173 | 169 | 168 | 180 | 82 |
| 81 | 143 | 152 | 161 | 161 | 172 | 168 | 167 | 179 | 81 |
| 80 | 142 | 151 | 160 | 160 | 170 | 167 | 166 | 177 | 80 |
| 79 | 141 | 150 | 158 | 159 | 169 | 166 | 165 | 176 | 79 |
| 78 | 139 | 149 | 157 | 158 | 167 | 165 | 164 | 175 | 78 |
| 77 | 138 | 147 | 155 | 156 | 166 | 164 | 163 | 174 | 77 |
| 76 | 137 | 146 | 154 | 155 | 165 | 163 | 162 | 173 | 76 |
| 75 | 136 | 145 | 153 | 154 | 163 | 162 | 161 | 172 | 75 |
| 74 | 135 | 143 | 151 | 153 | 162 | 161 | 160 | 171 | 74 |
| 73 | 134 | 142 | 150 | 152 | 160 | 160 | 158 | 169 | 73 |
| 72 | 132 | 141 | 149 | 151 | 159 | 159 | 157 | 168 | 72 |
| 71 | 131 | 139 | 147 | 150 | 157 | 158 | 156 | 157 | 71 |
| 70 | 130 | 138 | 146 | 148 | 156 | 157 | 155 | 166 | 70 |
| 69 | 129 | 137 | 145 | 167 | 155 | 156 | 154 | 165 | 69 |
| 68 | 128 | 136 | 143 | 146 | 153 | 155 | 153 | 164 | 68 |
| 67 | 127 | 134 | 142 | 145 | 152 | 154 | 152 | 163 | 67 |
| 66 | 126 | 133 | 141 | 144 | 150 | 153 | 151 | 161 | 66 |
| 65 | 124 | 132 | 139 | 143 | 149 | 152 | 150 | 160 | 65 |
| 64 | 123 | 130 | 138 | 141 | 148 | 151 | 148 | 159 | 64 |
| 63 | 122 | 129 | 137 | 140 | 146 | 150 | 147 | 158 | 63 |
| 62 | 121 | 128 | 135 | 139 | 145 | 149 | 146 | 157 | 62 |
| 61 | 120 | 127 | 134 | 138 | 143 | 148 | 145 | 156 | 61 |
| 60 | 119 | 125 | 133 | 137 | 142 | 147 | 144 | 155 | 60 |
| 59 | 117 | 124 | 131 | 136 | 140 | 146 | 143 | 154 | 59 |
| 58 | 116 | 123 | 130 | 135 | 139 | 145 | 142 | 152 | 58 |
| 57 | 115 | 121 | 128 | 133 | 138 | 144 | 141 | 151 | 57 |
| 56 | 114 | 120 | 127 | 132 | 136 | 143 | 140 | 150 | 56 |
| 55 | 113 | 119 | 126 | 131 | 135 | 142 | 139 | 149 | 55 |
| 54 | 112 | 118 | 124 | 130 | 133 | 141 | 137 | 148 | 54 |
| 53 | 110 | 116 | 123 | 129 | 132 | 140 | 136 | 147 | 53 |
| 52 | 109 | 115 | 122 | 128 | 131 | 139 | 135 | 146 | 52 |
| 51 | 108 | 114 | 120 | 126 | 129 | 138 | 134 | 144 | 51 |

*6σ/100 right grip strength scales for males by weight*

| SCALE SCORE | WEIGHT | | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|---|
| | 140-9 | 150-9 | 160-9 | 170-9 | 180-9 | 190-9 | 200-9 | 210 up | |
| 50 | 107 | 112 | 119 | 125 | 128 | 137 | 133 | 143 | 50 |
| 49 | 106 | 111 | 118 | 124 | 126 | 136 | 132 | 142 | 49 |
| 48 | 105 | 110 | 116 | 123 | 125 | 135 | 131 | 141 | 48 |
| 47 | 103 | 109 | 115 | 122 | 123 | 134 | 130 | 140 | 47 |
| 46 | 102 | 107 | 114 | 120 | 122 | 133 | 129 | 139 | 46 |
| 45 | 101 | 106 | 112 | 119 | 121 | 132 | 127 | 138 | 45 |
| 44 | 100 | 105 | 111 | 118 | 119 | 131 | 126 | 136 | 44 |
| 43 | 99 | 103 | 110 | 117 | 118 | 130 | 125 | 135 | 43 |
| 42 | 98 | 102 | 108 | 116 | 116 | 129 | 124 | 134 | 42 |
| 41 | 96 | 101 | 107 | 115 | 115 | 128 | 123 | 133 | 41 |
| 40 | 95 | 100 | 106 | 113 | 113 | 127 | 122 | 132 | 40 |
| 39 | 94 | 98 | 104 | 112 | 112 | 126 | 121 | 131 | 39 |
| 38 | 93 | 97 | 103 | 111 | 111 | 125 | 120 | 130 | 38 |
| 37 | 92 | 96 | 101 | 110 | 109 | 124 | 119 | 129 | 37 |
| 36 | 91 | 94 | 100 | 109 | 108 | 123 | 118 | 127 | 36 |
| 35 | 89 | 93 | 99 | 108 | 106 | 122 | 116 | 126 | 35 |
| 34 | 88 | 92 | 97 | 107 | 105 | 121 | 115 | 125 | 34 |
| 33 | 87 | 91 | 96 | 105 | 104 | 120 | 114 | 124 | 33 |
| 32 | 86 | 89 | 95 | 104 | 102 | 119 | 113 | 123 | 32 |
| 31 | 85 | 88 | 93 | 103 | 101 | 118 | 112 | 122 | 31 |
| 30 | 84 | 87 | 92 | 102 | 99 | 117 | 111 | 121 | 30 |
| 29 | 82 | 85 | 91 | 101 | 98 | 116 | 110 | 119 | 29 |
| 28 | 81 | 84 | 89 | 100 | 96 | 115 | 109 | 118 | 28 |
| 27 | 80 | 83 | 88 | 98 | 95 | 114 | 108 | 117 | 27 |
| 26 | 79 | 82 | 87 | 97 | 94 | 113 | 106 | 116 | 26 |
| 25 | 78 | 80 | 85 | 96 | 92 | 112 | 105 | 115 | 25 |
| 24 | 77 | 79 | 84 | 95 | 91 | 111 | 104 | 114 | 24 |
| 23 | 75 | 78 | 83 | 94 | 89 | 110 | 103 | 113 | 23 |
| 22 | 74 | 76 | 81 | 93 | 88 | 109 | 102 | 111 | 22 |
| 21 | 73 | 75 | 80 | 92 | 87 | 108 | 101 | 110 | 21 |
| 20 | 72 | 74 | 79 | 90 | 85 | 107 | 100 | 109 | 20 |
| 19 | 71 | 73 | 77 | 89 | 84 | 106 | 99 | 108 | 19 |
| 18 | 70 | 71 | 76 | 88 | 82 | 105 | 98 | 107 | 18 |
| 17 | 68 | 70 | 74 | 87 | 81 | 104 | 96 | 106 | 17 |
| 16 | 67 | 69 | 73 | 86 | 79 | 103 | 95 | 105 | 16 |
| 15 | 66 | 67 | 72 | 85 | 78 | 102 | 94 | 103 | 15 |
| 14 | 65 | 66 | 70 | 83 | 77 | 101 | 93 | 102 | 14 |
| 13 | 64 | 65 | 69 | 82 | 75 | 100 | 92 | 101 | 13 |
| 12 | 63 | 64 | 68 | 81 | 74 | 99 | 91 | 100 | 12 |
| 11 | 61 | 12 | 66 | 80 | 72 | 98 | 90 | 99 | 11 |
| 10 | 60 | 61 | 65 | 79 | 71 | 97 | 89 | 98 | 10 |
| 9 | 59 | 60 | 64 | 78 | 69 | 96 | 88 | 97 | 9 |
| 8 | 58 | 58 | 62 | 76 | 68 | 95 | 87 | 96 | 8 |
| 7 | 57 | 57 | 61 | 75 | 67 | 94 | 85 | 94 | 7 |
| 6 | 56 | 56 | 60 | 74 | 65 | 93 | 84 | 93 | 6 |
| 5 | 55 | 55 | 58 | 73 | 64 | 92 | 83 | 92 | 5 |
| 4 | 53 | 53 | 57 | 72 | 62 | 91 | 82 | 91 | 4 |
| 3 | 52 | 52 | 56 | 71 | 61 | 90 | 81 | 90 | 3 |
| 2 | 51 | 51 | 54 | 70 | 60 | 89 | 80 | 89 | 2 |
| 1 | 50 | 49 | 53 | 68 | 58 | 88 | 79 | 88 | 1 |

*6σ/100 left grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|
| | Up to 594 | 595–629 | 630–664 | 665–699 | 700–734 | 735–769 | 770–804 | |
| 100 | | 83 | 100 | 95 | 102 | 121 | 129 | 100 |
| 99 | 58 | 82 | 99 | 94 | 101 | 120 | 128 | 99 |
| 98 | | | 97 | 93 | 100 | 118 | 126 | 98 |
| 97 | | 81 | 96 | 92 | 98 | 117 | 125 | 97 |
| 96 | 57 | 80 | 95 | 91 | 97 | 116 | 123 | 96 |
| 95 | | 79 | 94 | 90 | 96 | 114 | 122 | 95 |
| 94 | 56 | 78 | 93 | 89 | 95 | 113 | 121 | 94 |
| 93 | | | 91 | 88 | 94 | 112 | 119 | 93 |
| 92 | | 77 | 90 | 87 | 93 | 110 | 118 | 92 |
| 91 | 55 | 76 | 89 | 85 | 91 | 109 | 116 | 91 |
| 90 | | 75 | 88 | 84 | 90 | 108 | 115 | 90 |
| 89 | 54 | 74 | 86 | 83 | 89 | 106 | 113 | 89 |
| 88 | | 73 | 85 | 82 | 88 | 105 | 112 | 88 |
| 87 | | | 84 | 81 | 87 | 104 | 111 | 87 |
| 86 | 53 | 72 | 83 | 80 | 85 | 102 | 109 | 86 |
| 85 | | 71 | 81 | 79 | 84 | 101 | 108 | 85 |
| 84 | 52 | 70 | 80 | 78 | 83 | 100 | 106 | 84 |
| 83 | | 69 | 79 | 77 | 82 | 98 | 105 | 83 |
| 82 | | 68 | 78 | 76 | 81 | 97 | 104 | 82 |
| 81 | 51 | | 76 | 75 | 80 | 96 | 102 | 81 |
| 80 | | 67 | 75 | 73 | 78 | 94 | 101 | 80 |
| 79 | 50 | 66 | 74 | 72 | 77 | 93 | 99 | 79 |
| 78 | | 65 | 73 | 71 | 76 | 92 | 98 | 78 |
| 77 | | 64 | 71 | 70 | 75 | 90 | 97 | 77 |
| 76 | 49 | 63 | 70 | 69 | 74 | 89 | 95 | 76 |
| 75 | | | 69 | 68 | 72 | 88 | 94 | 75 |
| 74 | 48 | 62 | 68 | 67 | 71 | 86 | 92 | 74 |
| 73 | | 61 | 66 | 66 | 70 | 85 | 91 | 73 |
| 72 | 47 | 60 | 65 | 65 | 69 | 84 | 90 | 72 |
| 71 | | 59 | 64 | 64 | 68 | 82 | 88 | 71 |
| 70 | | 58 | 63 | 63 | 67 | 81 | 87 | 70 |
| 69 | 46 | | 61 | 62 | 65 | 80 | 85 | 69 |
| 68 | | 57 | 60 | 60 | 64 | 78 | 84 | 68 |
| 67 | 45 | 56 | 59 | 59 | 63 | 77 | 82 | 67 |
| 66 | | 55 | 58 | 58 | 62 | 76 | 81 | 66 |
| 65 | | 54 | 56 | 57 | 61 | 74 | 80 | 65 |
| 64 | 44 | 53 | 55 | 56 | 59 | 73 | 78 | 64 |
| 63 | | | 54 | 55 | 58 | 72 | 77 | 63 |
| 62 | 43 | 52 | 53 | 54 | 57 | 70 | 75 | 62 |
| 61 | | 51 | 51 | 53 | 56 | 69 | 74 | 61 |
| 60 | | 50 | 50 | 52 | 55 | 68 | 73 | 60 |
| 59 | 42 | 49 | 49 | 51 | 54 | 66 | 71 | 59 |
| 58 | | 48 | 48 | 49 | 52 | 65 | 70 | 58 |
| 57 | 41 | | 46 | 48 | 51 | 64 | 68 | 57 |
| 56 | | 47 | 45 | 47 | 50 | 62 | 67 | 56 |
| 55 | | 46 | 44 | 46 | 49 | 61 | 66 | 55 |
| 54 | 40 | 45 | 43 | 45 | 48 | 59 | 64 | 54 |
| 53 | | 44 | 41 | 44 | 46 | 58 | 63 | 53 |
| 52 | 39 | 43 | 40 | 43 | 45 | 57 | 61 | 52 |
| 51 | | | 39 | 42 | 44 | 55 | 60 | 51 |

*6σ/100 left grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|
| | Up to 594 | 595–629 | 630–664 | 665–699 | 700–734 | 735–769 | 770–804 | |
| 50 | | 42 | 38 | 41 | 43 | 54 | 58 | 50 |
| 49 | 38 | 41 | 36 | 40 | 42 | 53 | 57 | 49 |
| 48 | | 40 | 35 | 39 | 41 | 51 | 56 | 48 |
| 47 | 37 | 39 | 34 | 38 | 39 | 50 | 54 | 47 |
| 46 | | | 33 | 36 | 38 | 49 | 53 | 46 |
| 45 | 36 | 38 | 32 | 35 | 37 | 47 | 51 | 45 |
| 44 | | 37 | 30 | 34 | 36 | 46 | 50 | 44 |
| 43 | | 36 | 29 | 33 | 35 | 45 | 49 | 43 |
| 42 | 35 | 35 | 28 | 32 | 34 | 43 | 47 | 42 |
| 41 | | 34 | 27 | 31 | 32 | 42 | 46 | 41 |
| 40 | 34 | | 25 | 30 | 31 | 41 | 44 | 40 |
| 39 | | 33 | 24 | 29 | 30 | 39 | 43 | 39 |
| 38 | | 32 | 23 | 28 | 29 | 38 | 42 | 38 |
| 37 | 33 | 31 | 22 | 27 | 28 | 37 | 40 | 37 |
| 36 | | 30 | 20 | 26 | 26 | 35 | 39 | 36 |
| 35 | 32 | 29 | 19 | 24 | 25 | 34 | 37 | 35 |
| 34 | | | 18 | 23 | 24 | 33 | 36 | 34 |
| 33 | | 28 | 17 | 22 | 23 | 31 | 35 | 33 |
| 32 | 31 | 27 | 15 | 21 | 22 | 30 | 33 | 32 |
| 31 | | 26 | 14 | 20 | 21 | 29 | 32 | 31 |
| 30 | 30 | 25 | 13 | 19 | 19 | 27 | 30 | 30 |
| 29 | | 24 | 12 | 18 | 18 | 26 | 29 | 29 |
| 28 | | | 10 | 17 | 17 | 25 | 27 | 28 |
| 27 | 29 | 23 | 9 | 16 | 16 | 23 | 26 | 27 |
| 26 | | 22 | 8 | 15 | 15 | 22 | 25 | 26 |
| 25 | 28 | 21 | 7 | 14 | 13 | 21 | 23 | 25 |
| 24 | | 20 | 5 | 12 | 12 | 19 | 22 | 24 |
| 23 | 27 | 19 | 4 | 11 | 11 | 18 | 20 | 23 |
| 22 | | | 3 | 10 | 10 | 17 | 19 | 22 |
| 21 | | 18 | 2 | 9 | 9 | 15 | 18 | 21 |
| 20 | 26 | 17 | 1 | 8 | 8 | 14 | 16 | 20 |
| 19 | | 16 | | 7 | 6 | 13 | 15 | 19 |
| 18 | 25 | 15 | | 6 | 5 | 11 | 13 | 18 |
| 17 | | | | 5 | 4 | 10 | 12 | 17 |
| 16 | | 14 | | 4 | 3 | 9 | 11 | 16 |
| 15 | 24 | 13 | | 3 | 2 | 7 | 9 | 15 |
| 14 | | 12 | | 2 | | 6 | 8 | 14 |
| 13 | 23 | 11 | | 1 | | 5 | 6 | 13 |
| 12 | | 10 | | | | 3 | 5 | 12 |
| 11 | | 9 | | | | 2 | 3 | 11 |
| 10 | 22 | | | | | 1 | 2 | 10 |
| 9 | | 8 | | | | | 1 | 9 |
| 8 | 21 | 7 | | | | | | 8 |
| 7 | | 6 | | | | | | 7 |
| 6 | | 5 | | | | | | 6 |
| 5 | 20 | | | | | | | 5 |
| 4 | | 4 | | | | | | 4 |
| 3 | 19 | 3 | | | | | | 3 |
| 2 | | 2 | | | | | | 2 |
| 1 | | 1 | | | | | | 1 |

*6σ/100 left grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|
| | 805–839 | 840–874 | 875–909 | 910–944 | 945–979 | 980 and up | |
| 100 | 145 | 156 | 162 | 169 | 181 | 191 | 100 |
| 99 | 143 | 155 | 161 | 168 | 180 | 190 | 99 |
| 98 | 142 | 154 | 159 | 167 | 179 | 188 | 98 |
| 97 | 140 | 152 | 158 | 166 | 177 | 187 | 97 |
| 96 | 139 | 151 | 157 | 164 | 176 | 186 | 96 |
| 95 | 138 | 150 | 156 | 163 | 175 | 185 | 95 |
| 94 | 136 | 148 | 155 | 162 | 174 | 183 | 94 |
| 93 | 135 | 147 | 154 | 161 | 173 | 182 | 93 |
| 92 | 133 | 146 | 153 | 160 | 171 | 181 | 92 |
| 91 | 132 | 144 | 151 | 159 | 170 | 179 | 91 |
| 90 | 131 | 143 | 150 | 157 | 169 | 178 | 90 |
| 89 | 129 | 142 | 149 | 156 | 168 | 177 | 89 |
| 88 | 128 | 141 | 148 | 155 | 166 | 176 | 88 |
| 87 | 126 | 139 | 147 | 154 | 165 | 174 | 87 |
| 86 | 125 | 138 | 146 | 153 | 164 | 173 | 86 |
| 85 | 124 | 137 | 145 | 152 | 163 | 172 | 85 |
| 84 | 122 | 135 | 143 | 151 | 162 | 170 | 84 |
| 83 | 121 | 134 | 142 | 149 | 160 | 169 | 83 |
| 82 | 119 | 133 | 141 | 148 | 159 | 168 | 82 |
| 81 | 118 | 131 | 140 | 147 | 158 | 167 | 81 |
| 80 | 116 | 130 | 139 | 146 | 157 | 165 | 80 |
| 79 | 115 | 129 | 138 | 145 | 156 | 164 | 79 |
| 78 | 114 | 127 | 136 | 144 | 154 | 163 | 78 |
| 77 | 112 | 126 | 135 | 143 | 153 | 161 | 77 |
| 76 | 111 | 125 | 134 | 141 | 152 | 160 | 76 |
| 75 | 109 | 124 | 133 | 140 | 151 | 159 | 75 |
| 74 | 108 | 122 | 132 | 139 | 150 | 158 | 74 |
| 73 | 107 | 121 | 131 | 138 | 148 | 156 | 73 |
| 72 | 105 | 120 | 130 | 137 | 147 | 155 | 72 |
| 71 | 104 | 118 | 128 | 136 | 146 | 154 | 71 |
| 70 | 102 | 117 | 127 | 134 | 145 | 152 | 70 |
| 69 | 101 | 116 | 126 | 133 | 143 | 151 | 69 |
| 68 | 100 | 114 | 125 | 132 | 142 | 150 | 68 |
| 67 | 98 | 113 | 124 | 131 | 141 | 148 | 67 |
| 66 | 97 | 112 | 123 | 130 | 140 | 147 | 66 |
| 65 | 95 | 110 | 122 | 129 | 139 | 146 | 65 |
| 64 | 94 | 109 | 120 | 128 | 137 | 145 | 64 |
| 63 | 93 | 108 | 119 | 126 | 136 | 143 | 63 |
| 62 | 91 | 107 | 118 | 125 | 135 | 142 | 62 |
| 61 | 90 | 105 | 117 | 124 | 134 | 141 | 61 |
| 60 | 88 | 104 | 116 | 123 | 133 | 139 | 60 |
| 59 | 87 | 103 | 115 | 122 | 131 | 138 | 59 |
| 58 | 85 | 101 | 113 | 121 | 130 | 137 | 58 |
| 57 | 84 | 100 | 112 | 120 | 129 | 136 | 57 |
| 56 | 83 | 99 | 111 | 118 | 128 | 134 | 56 |
| 55 | 81 | 97 | 110 | 117 | 127 | 133 | 55 |
| 54 | 80 | 96 | 109 | 116 | 125 | 132 | 54 |
| 53 | 78 | 95 | 108 | 115 | 124 | 130 | 53 |
| 52 | 77 | 93 | 107 | 114 | 123 | 129 | 52 |
| 51 | 76 | 92 | 105 | 113 | 122 | 128 | 51 |

*6σ/100 left grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|
| | 805–839 | 840–874 | 875–909 | 910–944 | 945–979 | 980 and up | |
| 50 | 74 | 91 | 104 | 111 | 120 | 127 | 50 |
| 49 | 73 | 89 | 103 | 110 | 119 | 125 | 49 |
| 48 | 71 | 88 | 102 | 109 | 118 | 124 | 48 |
| 47 | 70 | 87 | 101 | 108 | 117 | 123 | 47 |
| 46 | 69 | 86 | 100 | 107 | 116 | 121 | 46 |
| 45 | 67 | 84 | 99 | 106 | 114 | 120 | 45 |
| 44 | 66 | 83 | 97 | 104 | 113 | 119 | 44 |
| 43 | 64 | 82 | 96 | 103 | 112 | 118 | 43 |
| 42 | 63 | 80 | 95 | 102 | 111 | 116 | 42 |
| 41 | 62 | 79 | 94 | 101 | 110 | 115 | 41 |
| 40 | 60 | 78 | 93 | 100 | 108 | 114 | 40 |
| 39 | 59 | 76 | 92 | 99 | 107 | 112 | 39 |
| 38 | 57 | 75 | 90 | 98 | 106 | 111 | 38 |
| 37 | 56 | 74 | 89 | 97 | 105 | 110 | 37 |
| 36 | 54 | 72 | 88 | 95 | 104 | 109 | 36 |
| 35 | 53 | 71 | 87 | 94 | 102 | 107 | 35 |
| 34 | 52 | 70 | 86 | 93 | 101 | 106 | 34 |
| 33 | 50 | 69 | 85 | 92 | 100 | 105 | 33 |
| 32 | 49 | 67 | 84 | 91 | 99 | 103 | 32 |
| 31 | 47 | 66 | 82 | 90 | 98 | 102 | 31 |
| 30 | 46 | 65 | 81 | 88 | 96 | 101 | 30 |
| 29 | 45 | 63 | 80 | 87 | 95 | 99 | 29 |
| 28 | 43 | 62 | 79 | 86 | 94 | 98 | 28 |
| 27 | 42 | 61 | 78 | 85 | 93 | 97 | 27 |
| 26 | 40 | 59 | 77 | 84 | 91 | 96 | 26 |
| 25 | 39 | 58 | 76 | 83 | 90 | 94 | 25 |
| 24 | 38 | 56 | 74 | 82 | 89 | 93 | 24 |
| 23 | 36 | 55 | 73 | 80 | 88 | 92 | 23 |
| 22 | 35 | 54 | 72 | 79 | 87 | 90 | 22 |
| 21 | 33 | 53 | 71 | 78 | 85 | 89 | 21 |
| 20 | 32 | 51 | 70 | 77 | 84 | 88 | 20 |
| 19 | 30 | 50 | 69 | 76 | 83 | 87 | 19 |
| 18 | 29 | 49 | 67 | 75 | 82 | 85 | 18 |
| 17 | 28 | 48 | 66 | 74 | 81 | 84 | 17 |
| 16 | 26 | 46 | 65 | 72 | 79 | 83 | 16 |
| 15 | 25 | 45 | 64 | 71 | 78 | 81 | 15 |
| 14 | 23 | 44 | 63 | 70 | 77 | 80 | 14 |
| 13 | 22 | 42 | 62 | 69 | 76 | 79 | 13 |
| 12 | 21 | 41 | 61 | 68 | 75 | 78 | 12 |
| 11 | 19 | 40 | 59 | 67 | 73 | 76 | 11 |
| 10 | 18 | 38 | 58 | 65 | 72 | 75 | 10 |
| 9 | 16 | 37 | 57 | 64 | 71 | 74 | 9 |
| 8 | 15 | 36 | 56 | 63 | 70 | 72 | 8 |
| 7 | 14 | 34 | 55 | 62 | 68 | 71 | 7 |
| 6 | 12 | 33 | 54 | 61 | 67 | 70 | 6 |
| 5 | 11 | 32 | 53 | 60 | 66 | 69 | 5 |
| 4 | 9 | 31 | 51 | 59 | 65 | 67 | 4 |
| 3 | 8 | 29 | 50 | 57 | 64 | 66 | 3 |
| 2 | 7 | 28 | 49 | 56 | 62 | 65 | 2 |
| 1 | 5 | 27 | 48 | 55 | 61 | 63 | 1 |

*6σ/100 right grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|
| | Up to 594 | 595–629 | 630–664 | 665–699 | 700–734 | 735–769 | 770–804 | |
| 100 | 69 | 87 | 98 | 103 | 114 | 125 | 136 | 100 |
| 99 | | 86 | 97 | 102 | 113 | 124 | 135 | 99 |
| 98 | 68 | 85 | 96 | 101 | 111 | 123 | 134 | 98 |
| 97 | | 84 | 95 | 100 | 110 | 121 | 132 | 97 |
| 96 | 67 | 83 | 94 | 98 | 109 | 120 | 131 | 96 |
| 95 | | | 93 | 97 | 107 | 119 | 129 | 95 |
| 94 | 66 | 82 | 92 | 96 | 106 | 117 | 128 | 94 |
| 93 | | 81 | 91 | 95 | 105 | 116 | 127 | 93 |
| 92 | 65 | 80 | 90 | 94 | 104 | 115 | 125 | 92 |
| 91 | | 79 | 89 | 93 | 102 | 113 | 124 | 91 |
| 90 | 64 | | 88 | 92 | 101 | 112 | 123 | 90 |
| 89 | | 78 | 87 | 91 | 100 | 111 | 121 | 89 |
| 88 | 63 | 77 | 86 | 90 | 99 | 109 | 120 | 88 |
| 87 | | 76 | 85 | 89 | 97 | 108 | 118 | 87 |
| 86 | 62 | 75 | 84 | 87 | 96 | 107 | 117 | 86 |
| 85 | | 74 | 83 | 86 | 95 | 105 | 116 | 85 |
| 84 | 61 | | 82 | 85 | 93 | 104 | 114 | 84 |
| 83 | | 73 | 81 | 84 | 92 | 103 | 113 | 83 |
| 82 | 60 | 72 | 80 | 83 | 91 | 101 | 112 | 82 |
| 81 | | 71 | 78 | 82 | 90 | 100 | 110 | 81 |
| 80 | 59 | 70 | 77 | 81 | 88 | 99 | 109 | 80 |
| 79 | | 69 | 76 | 80 | 87 | 97 | 107 | 79 |
| 78 | 58 | | 75 | 79 | 86 | 96 | 106 | 78 |
| 77 | | 68 | 74 | 78 | 85 | 94 | 105 | 77 |
| 76 | 57 | 67 | 73 | 76 | 83 | 93 | 103 | 76 |
| 75 | | 66 | 72 | 75 | 82 | 92 | 102 | 75 |
| 74 | 56 | 65 | 71 | 74 | 81 | 90 | 100 | 74 |
| 73 | | | 70 | 73 | 80 | 89 | 99 | 73 |
| 72 | 55 | 64 | 69 | 72 | 78 | 88 | 98 | 72 |
| 71 | | 63 | 68 | 71 | 77 | 86 | 96 | 71 |
| 70 | 54 | 62 | 67 | 70 | 76 | 85 | 95 | 70 |
| 69 | | 61 | 66 | 69 | 74 | 84 | 93 | 69 |
| 68 | 53 | 60 | 65 | 68 | 73 | 82 | 92 | 68 |
| 67 | | | 64 | 67 | 72 | 81 | 91 | 67 |
| 66 | 52 | 59 | 63 | 65 | 71 | 80 | 89 | 66 |
| 65 | | 58 | 62 | 64 | 69 | 78 | 88 | 65 |
| 64 | 51 | 57 | 61 | 63 | 68 | 77 | 87 | 64 |
| 63 | | 56 | 60 | 62 | 67 | 76 | 85 | 63 |
| 62 | 50 | 55 | 59 | 61 | 66 | 74 | 84 | 62 |
| 61 | | | 57 | 60 | 64 | 73 | 83 | 61 |
| 60 | 49 | 54 | 56 | 59 | 63 | 72 | 81 | 60 |
| 59 | | 53 | 55 | 58 | 62 | 70 | 80 | 59 |
| 58 | 48 | 52 | 54 | 57 | 60 | 69 | 78 | 58 |
| 57 | | 51 | 53 | 56 | 59 | 68 | 77 | 57 |
| 56 | 47 | | 52 | 55 | 58 | 66 | 76 | 56 |
| 55 | | 50 | 51 | 53 | 57 | 65 | 74 | 55 |
| 54 | 46 | 49 | 50 | 52 | 55 | 64 | 73 | 54 |
| 53 | | 48 | 49 | 51 | 54 | 62 | 72 | 53 |
| 52 | 45 | 47 | 48 | 50 | 53 | 61 | 70 | 52 |
| 51 | | 46 | 47 | 49 | 52 | 60 | 69 | 51 |

*6σ/100 right grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|---|
| | Up to 594 | 595–629 | 630–664 | 665–699 | 700–734 | 735–769 | 770–804 | |
| 50 | 44 | | 46 | 48 | 50 | 58 | 68 | 50 |
| 49 | | 45 | 45 | 47 | 49 | 57 | 66 | 49 |
| 48 | 43 | 44 | 44 | 46 | 48 | 56 | 65 | 48 |
| 47 | | 43 | 43 | 45 | 47 | 54 | 63 | 47 |
| 46 | 42 | 42 | 42 | 44 | 45 | 53 | 62 | 46 |
| 45 | | | 41 | 42 | 44 | 52 | 61 | 45 |
| 44 | 41 | 41 | 40 | 41 | 43 | 50 | 59 | 44 |
| 43 | | 40 | 39 | 30 | 41 | 49 | 58 | 43 |
| 42 | 40 | 39 | 38 | 39 | 40 | 48 | 56 | 42 |
| 41 | | 38 | 36 | 38 | 39 | 46 | 55 | 41 |
| 40 | 39 | 37 | 35 | 37 | 38 | 45 | 54 | 40 |
| 39 | | | 34 | 36 | 36 | 43 | 52 | 39 |
| 38 | 38 | 36 | 33 | 35 | 35 | 42 | 51 | 38 |
| 37 | | 35 | 32 | 34 | 34 | 41 | 50 | 37 |
| 36 | 37 | 34 | 31 | 33 | 33 | 39 | 48 | 36 |
| 35 | | 33 | 30 | 31 | 31 | 38 | 47 | 35 |
| 34 | 36 | | 29 | 30 | 30 | 37 | 45 | 34 |
| 33 | | 32 | 28 | 29 | 29 | 35 | 44 | 33 |
| 32 | 35 | 31 | 27 | 28 | 27 | 34 | 43 | 32 |
| 31 | | 30 | 26 | 27 | 26 | 33 | 41 | 31 |
| 30 | 34 | 29 | 25 | 26 | 25 | 31 | 40 | 30 |
| 29 | | 28 | 24 | 25 | 24 | 30 | 39 | 29 |
| 28 | 33 | | 23 | 24 | 22 | 29 | 37 | 28 |
| 27 | | 27 | 22 | 23 | 21 | 27 | 36 | 27 |
| 26 | 32 | 26 | 21 | 22 | 20 | 26 | 34 | 26 |
| 25 | | 25 | 20 | 20 | 19 | 25 | 33 | 25 |
| 24 | 31 | 24 | 19 | 19 | 17 | 23 | 32 | 24 |
| 23 | | 23 | 18 | 18 | 16 | 22 | 30 | 23 |
| 22 | 30 | | 17 | 17 | 15 | 21 | 29 | 22 |
| 21 | | 22 | 15 | 16 | 13 | 19 | 28 | 21 |
| 20 | 29 | 21 | 14 | 15 | 12 | 18 | 26 | 20 |
| 19 | | 20 | 13 | 14 | 11 | 17 | 25 | 19 |
| 18 | 28 | 19 | 12 | 13 | 10 | 15 | 23 | 18 |
| 17 | | | 11 | 12 | 8 | 14 | 22 | 17 |
| 16 | 27 | 18 | 10 | 11 | 7 | 13 | 21 | 16 |
| 15 | | 17 | 9 | 10 | 6 | 11 | 19 | 15 |
| 14 | 26 | 16 | 8 | 8 | 5 | 10 | 18 | 14 |
| 13 | | 15 | 7 | 7 | 3 | 9 | 17 | 13 |
| 12 | 25 | 14 | 6 | 6 | 2 | 7 | 15 | 12 |
| 11 | | | 5 | 5 | 1 | 6 | 14 | 11 |
| 10 | 24 | 13 | 4 | 4 | | 5 | 12 | 10 |
| 9 | | 12 | 3 | 3 | | 3 | 11 | 9 |
| 8 | 23 | 11 | 2 | 2 | | 2 | 10 | 8 |
| 7 | | 10 | 1 | 1 | | 1 | 8 | 7 |
| 6 | 22 | | | | | | 7 | 6 |
| 5 | | 9 | | | | | 6 | 5 |
| 4 | 21 | 8 | | | | | 4 | 4 |
| 3 | | 7 | | | | | 3 | 3 |
| 2 | 20 | 6 | | | | | 1 | 2 |
| 1 | | 5 | | | | | | 1 |

*6σ/100 right grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|
| | 805–839 | 840–874 | 875–909 | 910–944 | 945–979 | 980 and up | |
| 100 | 151 | 164 | 167 | 180 | 194 | 210 | 100 |
| 99 | 149 | 162 | 166 | 178 | 192 | 208 | 99 |
| 98 | 148 | 161 | 165 | 177 | 191 | 207 | 98 |
| 97 | 147 | 160 | 164 | 176 | 190 | 206 | 97 |
| 96 | 145 | 159 | 163 | 175 | 189 | 204 | 96 |
| 95 | 144 | 157 | 162 | 174 | 187 | 203 | 95 |
| 94 | 142 | 156 | 161 | 173 | 186 | 202 | 94 |
| 93 | 141 | 155 | 159 | 171 | 185 | 200 | 93 |
| 92 | 140 | 154 | 158 | 170 | 184 | 199 | 92 |
| 91 | 138 | 152 | 157 | 169 | 182 | 198 | 91 |
| 90 | 137 | 151 | 156 | 168 | 181 | 197 | 90 |
| 89 | 135 | 150 | 155 | 167 | 180 | 195 | 89 |
| 88 | 134 | 148 | 154 | 166 | 179 | 194 | 88 |
| 87 | 133 | 147 | 153 | 164 | 177 | 193 | 87 |
| 86 | 131 | 146 | 152 | 163 | 176 | 191 | 86 |
| 85 | 130 | 145 | 150 | 162 | 175 | 190 | 85 |
| 84 | 128 | 143 | 149 | 161 | 174 | 189 | 84 |
| 83 | 127 | 142 | 148 | 160 | 172 | 187 | 83 |
| 82 | 126 | 141 | 147 | 159 | 171 | 186 | 82 |
| 81 | 124 | 140 | 146 | 157 | 170 | 185 | 81 |
| 80 | 123 | 138 | 145 | 156 | 169 | 183 | 80 |
| 79 | 121 | 137 | 144 | 155 | 167 | 182 | 79 |
| 78 | 120 | 136 | 143 | 154 | 166 | 181 | 78 |
| 77 | 119 | 134 | 141 | 153 | 165 | 179 | 77 |
| 76 | 117 | 133 | 140 | 151 | 164 | 178 | 76 |
| 75 | 116 | 132 | 139 | 150 | 162 | 177 | 75 |
| 74 | 114 | 131 | 138 | 149 | 161 | 175 | 74 |
| 73 | 113 | 129 | 137 | 148 | 160 | 174 | 73 |
| 72 | 112 | 128 | 136 | 147 | 159 | 173 | 72 |
| 71 | 110 | 127 | 135 | 146 | 157 | 171 | 71 |
| 70 | 109 | 126 | 134 | 144 | 156 | 170 | 70 |
| 69 | 107 | 124 | 133 | 143 | 155 | 169 | 69 |
| 68 | 106 | 123 | 131 | 142 | 153 | 167 | 68 |
| 67 | 105 | 122 | 130 | 141 | 152 | 166 | 67 |
| 66 | 103 | 120 | 129 | 140 | 151 | 165 | 66 |
| 65 | 102 | 119 | 128 | 138 | 150 | 163 | 65 |
| 64 | 100 | 118 | 127 | 137 | 149 | 162 | 64 |
| 63 | 99 | 117 | 126 | 136 | 147 | 161 | 63 |
| 62 | 98 | 115 | 125 | 135 | 146 | 159 | 62 |
| 61 | 96 | 114 | 124 | 134 | 145 | 158 | 61 |
| 60 | 95 | 113 | 122 | 133 | 144 | 157 | 60 |
| 59 | 93 | 112 | 121 | 132 | 142 | 155 | 59 |
| 58 | 92 | 110 | 120 | 130 | 141 | 154 | 58 |
| 57 | 91 | 109 | 119 | 129 | 140 | 153 | 57 |
| 56 | 89 | 108 | 118 | 128 | 139 | 151 | 56 |
| 55 | 88 | 106 | 117 | 127 | 137 | 150 | 55 |
| 54 | 86 | 105 | 116 | 126 | 136 | 149 | 54 |
| 53 | 85 | 104 | 115 | 125 | 135 | 147 | 53 |
| 52 | 84 | 103 | 113 | 123 | 134 | 146 | 52 |
| 51 | 82 | 101 | 112 | 122 | 132 | 145 | 51 |

*6σ/100 right grip strength scales for males by C. I.*

| SCALE SCORE | CLASSIFICATION INDEX | | | | | | SCALE SCORE |
|---|---|---|---|---|---|---|---|
| | 805-839 | 840-874 | 875-909 | 910-944 | 945-979 | 980 and up | |
| 50 | 81 | 100 | 111 | 121 | 131 | 143 | 50 |
| 49 | 80 | 99 | 110 | 120 | 130 | 142 | 49 |
| 48 | 78 | 98 | 109 | 119 | 129 | 141 | 48 |
| 47 | 77 | 96 | 108 | 118 | 127 | 139 | 47 |
| 46 | 75 | 95 | 107 | 116 | 126 | 138 | 46 |
| 45 | 74 | 94 | 106 | 115 | 125 | 137 | 45 |
| 44 | 73 | 92 | 104 | 114 | 124 | 135 | 44 |
| 43 | 71 | 91 | 103 | 113 | 122 | 134 | 43 |
| 42 | 70 | 90 | 102 | 112 | 121 | 133 | 42 |
| 41 | 68 | 89 | 101 | 111 | 120 | 131 | 41 |
| 40 | 67 | 87 | 100 | 109 | 119 | 130 | 40 |
| 39 | 66 | 86 | 99 | 108 | 117 | 129 | 39 |
| 38 | 64 | 85 | 98 | 107 | 116 | 127 | 38 |
| 37 | 63 | 84 | 97 | 106 | 115 | 126 | 37 |
| 36 | 61 | 82 | 96 | 105 | 114 | 125 | 36 |
| 35 | 60 | 81 | 94 | 104 | 112 | 123 | 35 |
| 34 | 59 | 80 | 93 | 102 | 111 | 122 | 34 |
| 33 | 57 | 78 | 92 | 101 | 110 | 121 | 33 |
| 32 | 56 | 77 | 91 | 100 | 109 | 119 | 32 |
| 31 | 54 | 76 | 90 | 99 | 107 | 118 | 31 |
| 30 | 53 | 75 | 89 | 98 | 106 | 117 | 30 |
| 29 | 52 | 73 | 88 | 97 | 105 | 115 | 29 |
| 28 | 50 | 72 | 87 | 95 | 104 | 114 | 28 |
| 27 | 49 | 71 | 85 | 94 | 102 | 113 | 27 |
| 26 | 47 | 70 | 84 | 93 | 101 | 111 | 26 |
| 25 | 46 | 68 | 83 | 92 | 100 | 110 | 25 |
| 24 | 45 | 67 | 82 | 91 | 99 | 109 | 24 |
| 23 | 43 | 66 | 81 | 89 | 97 | 107 | 23 |
| 22 | 42 | 64 | 80 | 88 | 96 | 106 | 22 |
| 21 | 40 | 63 | 79 | 87 | 95 | 105 | 21 |
| 20 | 39 | 62 | 78 | 86 | 94 | 103 | 20 |
| 19 | 38 | 61 | 76 | 85 | 92 | 102 | 19 |
| 18 | 36 | 59 | 75 | 84 | 91 | 101 | 18 |
| 17 | 35 | 58 | 74 | 82 | 90 | 99 | 17 |
| 16 | 33 | 57 | 73 | 81 | 89 | 98 | 16 |
| 15 | 32 | 56 | 72 | 80 | 87 | 97 | 15 |
| 14 | 31 | 54 | 71 | 79 | 86 | 95 | 14 |
| 13 | 29 | 53 | 70 | 78 | 85 | 94 | 13 |
| 12 | 28 | 52 | 69 | 77 | 84 | 93 | 12 |
| 11 | 26 | 50 | 67 | 75 | 82 | 91 | 11 |
| 10 | 25 | 49 | 66 | 74 | 81 | 90 | 10 |
| 9 | 24 | 48 | 65 | 73 | 80 | 89 | 9 |
| 8 | 22 | 47 | 64 | 72 | 79 | 87 | 8 |
| 7 | 21 | 45 | 63 | 71 | 77 | 86 | 7 |
| 6 | 19 | 44 | 62 | 69 | 76 | 85 | 6 |
| 5 | 18 | 43 | 61 | 68 | 75 | 83 | 5 |
| 4 | 17 | 42 | 60 | 67 | 73 | 82 | 4 |
| 3 | 15 | 40 | 59 | 66 | 72 | 81 | 3 |
| 2 | 14 | 39 | 57 | 65 | 71 | 79 | 2 |
| 1 | 12 | 38 | 56 | 64 | 70 | 78 | 1 |

strength is not as consistent as the right hand grip strength as it progresses through the Classification Index intervals.

RIGHT GRIP STRENGTH OF MALES BY CLASSIFICATION INDEX I

Right hand mean grip strength tends to increase with an increase in Classification Index I. There is slight progression in mean grip strength from up to 594 through the interval 700–734. Beyond this last interval there is marked and regular acceleration on through 980 and up. The lowest mean grip strength, 44 pounds, is in the lowest Classification Index group, up to 594, and the greatest mean grip strength, 143 pounds, is in the highest interval, 980 and up. Right hand grip strength variability is regular through the complete Classification Index range from up to 594 through 980 and up. Variability is small from up to 594 to 665, after which it increases a little and remains fairly equal throughout the range 665 through 980 and up. The least variable is the Classification Index group of up to 594. By comparison the variability in grip strength from Classification Index 700–734 through 980 and up is the smoothest of all the profiles.

## Summary and Conclusions

1. Age, weight, and Classification Index I are all factors influencing grip strength.
2. Right hand mean grip strength is consistently greater than left hand mean grip strength in relation to age, weight, and Classification Index I. This might indicate that the right hand is always stronger, however the true handedness of the sample is unknown.
3. Right hand and left hand grip strengths are more consistent in relation to Classification Index I, which includes age, height, and weight, than to either age or weight alone. It would seem therefore that Classification Index I is more valuable in determining grip strength than either age or weight. Right hand grip strength in relation to Classification Index I is the most consistent single measure of grip strength studied here.
4. Right and left hand grip strengths are less consistent in relation to age than to weight or Classification Index I. Age, then, according to this study is not as valuable a factor in determining grip strength as weight or Classification Index I.
5. The smallest mean grip strengths are found in the youngest age group, the lowest weight group, and the lowest Classification Index I group.
6. The greatest mean grip strengths are found in the oldest age group, the heaviest weight group, and the highest Classification Index I group.
7. Each of the profile curves is similar in shape, starting with slow progression of mean grip strength, increased acceleration and finally less rapid acceleration.
8. Each of the profile curves is similar in variability, starting with slight variability followed by a period of increased variability, then followed by fairly equal variability throughout the remainder of the curve.

# Relationship Between Teammate Status and Measures of Skill in Volleyball

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IN A RECENT study, Breck (1) suggested that sociometric techniques are applicable in physical education classes. This suggestion was based on the indicated reliability and ease of administration. The extent to which these measures can contribute to research and teaching in the field rests on the clarification of the factors which influence students' choices of teammates.

It has been demonstrated that teammate status has a small but consistent relationship with friendship status. Using 586 subjects, Breck found mean correlations of .43 ± .02 and .57 ± .02 between friendship scores[1] and teammate scores in two administrations of the tests. Frost (2) obtained a correlation of 0.40 ± .03 between friendship scores and teammate scores for both administrations of her test.

A question which arises is the extent to which teammate status is related to skill. Frost (2) initiated the study in this area by correlating the scores of the French (3) volleying test and measures of teammate status. The correlations obtained by Frost were .51 ± .02 on the first administration of the tests and .50 ± .02 on the administration of the test given six weeks later. The correlations between friendship scores and volleying scores were not significantly different from zero.

From these results it would seem that student choices of teammates are related somewhat to 1) friendship, as measured by stated choices of friends, and 2) skill, as measured by the French volleying test.

## Statement of Problem

The purpose of this study was to extend the investigation of the relationship between teammate status and skill in volleyball classes so as to include additional measures of skill. The measures of skill used were 1) teacher judgment, 2) French volleying test, and 3) French serving test.

## Importance of the Study

The validity of the French volleying test is low enough (.72) to make Frost's study inconclusive regarding the relationship between skill and teammate status. Since the volleying test was validated by correlating the scores on the test with teacher judgments, a more direct approach to

[1] See Breck (1) for the explanation of these "scores."

the relationship between teammate status and skill would be to use teacher judgment as the standard of skill.

## Method of Procedure

Two volleyball classes in the women's division of physical education at the University of California at Los Angeles were chosen for the study. The enrollment was 37 in one class and 31 in the other. Sixty-four students were present for all of the tests and constituted the subjects for the study. The experiment was conducted during the last four weeks of the semester.

The students were requested to list the five classmates they most preferred to have as teammates. A teammate status score was the number of times an individual was chosen as a teammate.

The instructor of the class and the author made independent judgment ratings of the skill of the class members on a ten point scale. The volleying test and the serving test were administered in accordance with the procedure recommended by French.

TABLE 1

*Intercorrelations of judgment ratings, teammate status scores, volleying scores, and serving scores*

| | JUDGMENT RATING | TEAMMATE STATUS SCORES | VOLLEYING SCORES |
|---|---|---|---|
| Serving Scores | .52 ± .06 | .23* ± .08 | .35 ± .07 |
| Volleying Scores | .71 ± .04 | .54* ± .06 | |
| Teammate Status Scores | .71* ± .04 | | |

* Rank order correlations.

## Results

*Reliability.* The split half method was used to estimate reliability of the teammate status scores. The cards on which the students listed their five choices were divided at random into two sets. Scores obtained from the two sets were correlated. The Pearson product moment coefficient of correlation obtained by this method was .87. This would be .93 when corrected by the Spearman-Brown formula. Since the scores are not normally distributed this correlation is spuriously high. A better estimate of reliability is probably obtained by the Rank Order method of correlation. The correlation obtained by this method was .66 or .80 when corrected.

The correlation between the two judgment ratings of skill was .78. This would be an estimated reliability of .88 for the combined judgment ratings. The split halfs of the serving test correlated .72, or .84 for the total test. The volleying test had a split half correlation of .90. The Spearman-Brown formula was not applied to this since only the best five of the ten trials were used as the volleying score.

*Relationship Between Factors.* The volleyball serving test scores correlated .35 with the scores of the volleying test, .52 with teacher judgment

ratings of skill, and .23 with scores of teammate status. The volleying test scores correlated .71 with ratings of skill made by the teachers and .54 with the scores of teammate status. Scores of teammate status correlated .71 with the rating of skill by the teachers. These correlations are summarized in Table 1.

## Conclusions and Recommendations

Teammate status, as measured by student choices, is as closely related to teacher judgment of skill in volleyball as are scores on the French volleying test. This is particularly interesting in view of the fact that the volleying test is considered by many to be the best available single test of volleyball skill.

The correlation of .54 between the scores of the volleying test and the measures of teammate status indicates that the two measures overlap but are not measuring exclusively the same variables. The evidence from Frost's study previously reviewed indicated the following: 1) volleying scores are not related to friendship scores and 2) teammate scores have a consistent relationship to friendship scores. This may mean that one element measured by the teammate status score which is not measured by the volleying scores is a social element. The social adjustment aspect might also influence the teacher judgments of skill. Unfortunately friendship scores were not included in this study so there is no evidence on this point.

Although scores of teammate status can be obtained in a fraction of the time that it takes to administer the volleying test, teammate status is *not* suggested as a substitute measure of skill. It would, however, seem to have real possibilities as a diagnostic tool to aid the teacher in giving guidance and direction. Skill tests supplemented with estimates of teammate status might give the teacher greater insight into the problems of the students.

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2. Frost, Ardith Bernice. *The Relationship between a Volley Ball Test and Students' Choices of Teammates and Friends*. Unpublished Master's Thesis, University of California at Los Angeles, 1947.
3. Scott, M. G., and Esther L. French. *Better Teaching Through Testing*. New York: A. S. Barnes and Company, 1945.

# The Effect of Shortness of the First Metatarsal Bone on Foot Function*

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SINCE the publishing of Morton's book[1] in 1935, there has been considerable controversy over the causes of foot breakdown in man. Authorities working in the field tend to be either in almost complete agreement or complete disagreement with Morton's concept with few, if any, taking the middle ground.

Morton's concept, stated briefly, is that foot stability is dependent upon the proper distribution of weight. In his so-called "ideal" foot, weight is distributed in the following manner: heel, one half; first metatarsal, one sixth; and second through fifth metatarsals, two sixths. This optimum weight distribution can exist only when the first metatarsal is as long as the second metatarsal and can act, therefore, as the medial line of stress. The medial and lateral lines of stress converge on the longest metatarsal. Therefore, if the second metatarsal is longer than the first, it bears an undue proportion of the total body load. This disturbance of normal lines of stress predisposes the foot to breakdown when subjected to unfavorable circumstances.

The statement is made further, that this is not a definite abnormality, that it is common and apparently an inherited tendency. Morton states that the defect (shortness of the first metatarsal) rarely produces symptoms before adulthood because of the general elasticity of tissue in early life. Later, as the tissues lose their resiliency under excessive strain of an occupational, health or activity nature, such a foot may cause trouble.

In contrast to Morton's theories, we have a number of other hypotheses in regard to causes of general foot breakdown. A number of authorities state that weakness of leg musculature, particularly the supinators of the foot, is the major cause of difficulty. Such persons subscribe to the idea of strengthening exercises in avoidance and treatment of foot difficulties.

Another group of competent observers believe that a tilting of the heel from the neutral into the valgus position is responsible for foot breakdown. This occurs at the subtalar joints and results from the fact that the line of gravity does not fall through the middle of the body of the calcaneus but medial to it by approximately 1.2 centimeters. This provides an essentially

* A more complete account of the study is contained in a dissertation that may be found in the library of the State University of Iowa (June, 1949).

[1] Dudley J. Morton, *The Human Foot*. New York: Columbia University Press, 1935.

unstable position of the posterior part of the foot with a strong rotatory component toward the valgus position.

Still another group subscribes to the theory that the ligaments of the foot provide the support for the foot and that the long leg muscles are relatively unimportant in the maintenance of the position of the foot.

With such a divergence of opinions, it is difficult to place the blame for foot disabilities. In observing both painful and symptomless feet of a large number of college women over a period of several years, it was noted that a high proportion of them, from external examination, might be classed as fitting into Morton's Syndrome. Yet, there was little disturbance of function in the majority of them. This might be explained by Morton's statement that feet possessing this defect are usually free of symptoms until adulthood because of the plasticity of the tissues.

With such a preponderance of deviations and so little objective evidence of any relationship between deviation and function, an investigation seemed pertinent.

## Statement of the Problem

The purpose of this investigation was to study the relationship, if any, between relative shortness of the first metatarsal bone of the foot and foot function as measured by various tests and ratings.

Metatarsal length was determined by measurement on x-ray photographs taken of the right foot in the non-weight-bearing position.

Foot function was measured by:

1. an adaptation of the vertical jump
2. an adaptation of the bounce test
3. footprints on which stress was rated and deviation from the midline computed
4. strength of the flexors of the toes as measured on a scale
5. observation and measurement of pronation in the standing position, and
6. observation of shoes for points of wear.

## Review of Literature

In considering the bones of the foot, it is of interest to note the varying opinions on the standards for the digital formula for the metatarsals. Morton[2] states that "for ideal foot function, the heads of the first and second metatarsals should be equidistant from the heels." This would imply the following digital formula $1 = 2 > 3 > 4 > 5$. According to Jones,[3] the typical digital formula for the toes is $1 > 2 > 3 > 4 > 5$, but this relationship does not hold true for the metatarsals. Typically, the second metatarsal projects beyond the others. This same author also states:

[2] *Ibid.*, p. 179.

[3] Frederic W. Jones, *Structure and Function as Seen in the Foot*, Baltimore: The Williams and Wilkins Company, 1941, p. 39.

> although the head of the second is, except in rare and abnormal cases, the more projected in the foot, there is a possibility of some slight variation around this mean. Next to the second may come the head of the first, which is itself in advance of the third. . . . or the heads of the first and third may project equally, both being behind the second. Lastly, the third may be in advance of both of them. This is the formula usually accepted by most anatomists as that typical of man.

Jones observes that shortness of the metatarsal, far from being an abnormality, is the accepted normal of all anatomists. If such were not the case, Jones notes, the bulk of humanity would be condemned by the normal disposition of the foot to show departure from normal functioning.

Straus' findings[4] concur with Jones' and indicate as typical digital patterns $2 > 1 > 3 > 4 > 5$ and $2 > 3 > 1 > 4 > 5$. He notes also, that at no time either in fetal or adult life is there a stage in which the heads of the first two metatarsals are equidistant from the heels.

Bruce[5] corroborates Morton's theory by stating that there are distinct evolutionary changes in the metatarsal region which account, in part, for the final form of that region. Among these are: 1) adduction of the first metatarsal, 2) decrease in length of the outer metatarsals, 3) hypertrophy of the first metatarsal, and 4) fixation of the first metatarsal. He points out that lack of adjustment in relative lengths of metatarsals as well as abduction or exaggerated mobility of the first metatarsal are anomalies that disturb the function of the whole anterior segment of the foot.

Elftman and Manter[6] note, among other things, as evolutionary changes in the foot proportion a shortening of the four lateral metatarsals and their phalangeal series.

Hiss[7] contends that shortness of the first metatarsal is more likely a developmental rather than congenital condition resulting from structural forces in the hip joint which necessitate lateral rotation of the leg at the hip. He believes that the metatarsal shortens to keep the plane of the hinge-like action in the metatarsal region at right angles to the direction of travel. Furthermore, he believes the condition develops so slowly that it gives the foot time to adapt to the condition and to develop sufficient function.

Morton cites as his reason for believing that the first metatarsal should be longer the fact that the medial and lateral lines of stress are concentrated on the longer metatarsal as a result of the fulcrum action in this region. The first metatarsal, because of its greater diameter, general sturdiness and larger basal joint surface, is capable of withstanding this strain. But the

[4] W. L. Straus, "The Growth of the Human Foot and Its Evolutionary Significance," *Contributions to Embryology, Carnegie Institute*, Vol. 19, 1927, p. 129.

[5] John Bruce, "Structural Anomalies of the Forefoot in Relation to Some Metatarsal Disturbances," *Edinburg Medical Journal*, **44:** (August, 1937), p. 533.

[6] Herbert Elftman, and John Manter, "The Evolution of the Human Foot," *Journal of Anatomy*, 70: (October, 1935), p. 66.

[7] John Martin Hiss, *Functional Foot Disturbances*, Los Angeles: University Publishing Company, 1937, p. 45.

second metatarsal is smaller and corresponds in size to the lateral three metatarsals and thus is not capable of bearing this strain structurally.

Morton prefers to think of the foot as a stable base of support with the leg as a "super-structure" maintained in balance over it by muscles rather than to reverse the procedure thus considering the foot movable on the leg with the foot position being maintained by muscular action. If for any reason the structure of the foot is unstable, it is possible for the muscles to maintain the leg in a vertical position over the foot for a short period of time, but like any other group of muscles in the body, the leg muscles are unable to sustain the contraction indefinitely. Hence, Morton believes, faulty foot positions such as pronation are not due to lack of strength but rather to a faulty base. This has been borne out by actual tests of muscle strength, where it was found that the persons with pronated feet frequently had greater strength in the supinator group of muscles.

Jones,[8] who is an advocate of the theory of muscular insufficiency as the cause of foot breakdown, states that the tendons of the muscles help in maintenance and restoration of the long arch not only by contracting from below, but also, in the case of the tibialis anterior and peroneus tertius, by pulling the dome of the long arch upward from above. He concludes that the last of the functional safeguards of the longitudinal arch are the short intrinsic muscles, which are very important functionally.

Willis[9] and Keith[10] agree with the concept that the muscles are all important in the support of the longitudinal arch and that support from ligaments comes into play only after the muscles have failed. Steindler[11] maintains that the muscles are the first line of defense in the maintenance of normal configuration of the foot with ligamentous resistance against external forces depended upon only after muscular resistance has failed.

Jones,[12] after carefully surveying the work of many of the above authors in regard to the theory of muscular support of the foot, found by experimentation that the tension stresses in the arch are borne chiefly by ligaments with the long leg muscles bearing not more than twenty per cent of the total tension stresses. He concludes, therefore, that the most important factors, quantitatively, in the support of the arch are the plantar ligaments and plantar aponeurosis with the short plantar muscles next most important.

Still another theory of possible cause of foot breakdown is advanced by Schwartz et al.,[13] as they disagree with the theory of muscular support

[8] Frederic W. Jones, *op. cit.*, p. 258.

[9] Theodore A. Willis, *Function of the Long Plantar Muscles*, pp. 150–6.

[10] Arthur Keith, "History of the Human Foot and Its Bearing on Orthopedic Practice," *Journal of Bone and Joint Surgery*, **11:** (January, 1929), p. 12.

[11] Arthur Steindler, *The Mechanics of Normal and Pathological Locomotion in Man*, Baltimore: Charles C. Thomas, 1935, p. 266.

[12] Russell L. Jones, "The Human Foot, An Experimental Study of Its Mechanics and the Role of Its Muscles and Ligaments in the Support of the Arch," *The American Journal of Anatomy*, **68:** (January, 1941) p. 22.

[13] Schwartz, and others, "Useful Methods of Examination as Related to the Cause and Treatment of Painful Feet," *Physiotherapy Review*, **19:** (January, February, 1939) p. 22.

of the foot as the first line of defense in foot stability. These authors state: "the presented evidence from precision records indicates that there isn't involuntary muscular protection against pronation in stance and locomotion." Their evidence indicated that pronation and foot strain cannot be avoided by muscular contraction alone. It is the valgus position of the calcaneus which they have found to be the primary factor in faulty foot position. Their study indicates that the posterior tibial muscle, which is a muscle generally accepted as effective in the correction of pronation, does not reflexly contract to prevent pronation either in stance or in the stance phase of locomotion.

Graham[14] and Jordan[15] both agree with Schwartz et al. that the majority of the foot disorders, regardless of their manifestations, originate in the valgus position of the heel.

Morton, while admitting the heel is important for its functional role in both stance and locomotion, still believes that the postural security of the heel as well as the entire foot is directly dependent on the radiating spread of the metatarsals.

It can readily be seen that there is considerable controversy over the cause of foot instability. Muscular insufficiency, lack of ligamentous support, tilting of the calcaneus and lack of support on the medial side of the foot due to shortness of the first metatarsal all have their proponents. It seems rather obvious that study of this problem is indicated.

## Procedure

In designing the experiment, it was planned to select two widely divergent groups with respect to comparative lengths of the first and second metatarsals. These groups were to be compared by using the critical ratio, applied to the mean scores of the various tests taken by the groups. It was necessary, therefore, to set up some screening device that would isolate these two groups for study. The following items were included in the examination: difference in length between the first and second metatarsals, contracted toes, callouses and prominence of the first metatarsal cuneiform joint, as measures directly related to selecting subjects for metatarsal length. Scaphoid and malleolus prominence, knee cap roll in or out, and weight on the inside of the foot in walking were selected as measures of pronation, while measures included for general interest value included corns, hallux valgus, angle of walk or toeing out, pain or fatigue, plantar warts, and athlete's foot.

Difference in length of metatarsals is difficult to detect particularly in the heavily muscled or fat foot. In such cases the examiner plantar flexed the subject's toes at the metatarsal phalangeal joint while applying pressure from below to bring out the heads of the metatarsals more clearly. The examiner then laid a steel rule on the dorsum of the first metatarsal

[14] James Graham, "Weak Foot: Pathogenesis and Treatment," *American Journal of Surgery*, **35:** (March, 1937) p. 498.

[15] Henry H. Jordan, "Foot Problems in Wartime," *Archives of Physical Therapy*, **24:** (September, 1943) p. 527.

and read the difference between the forward projection of its distal end and that of the second metatarsal. The rule had been previously prepared with each three millimeters representing one degree of difference so readings could be taken directly. This measure was then designated as estimated difference in metatarsal length. Callouses were indicated by recording the number of the metatarsal under which they were found. Scaphoid and malleolus prominences were graded by noting whether a vertical dropped from these two points lay lateral or medial to a line drawn to connect the most medial projection of the heel and first metatarsal phalangeal joint. For each quarter of an inch deviation medially from the heel-toe line, one degree of deviation was recorded. Lateral deviations were scored as zero. Hallux valgus was scored by placing the feet together and noting the deviation of the proximal phalanges. For each one-fourth inch of deviation, one degree of deviation was recorded. The remainder of the measures were recorded as absent, slight, moderate, or severe.

The screening examination was given as part of the Basic Skills Testing Program in the fall to all entering freshmen women at the State University of Iowa.

All of the cards of the subjects rated as having no estimated difference in length between the first and second metatarsals were reviewed for inclusion in the experimental group and those with marked deficiencies in other parts of the examination were discarded. Those with marked estimated difference in metatarsal length (three or four degrees) were automatically included in the group at the other extreme. In the group with no estimated difference in metatarsal length, fifty were tested, while of those with marked estimated difference, thirty seven were tested.

X-ray photographs were taken of the right foot of all subjects in the weight bearing and non-weight bearing positions. The following measurements were made on the x-ray film with white ink: actual difference in metatarsal length on the non-weight-bearing film and digital length of the weight bearing film. A vertical was erected bisecting the shaft of the second metatarsal and lines were drawn at right angles to the vertical and tangent to the heads of the first and second metatarsals. The difference between these lines was scored as the actual difference in metatarsal length. Digital length was measured by noting the difference between parallel lines drawn tangent to the soft tissue outlines of the first and second digits on the weight bearing film. When the first metatarsal or digit was longer than the second, the actual difference was recorded positively, while negative readings were recorded when the second digit or metatarsal was the longer.

An attempt was made to measure pronation by noting differences between the weight bearing and non-weight bearing films, but after a number of attempts, this was abandoned.

A careful survey of the literature revealed very few tests of foot function. From those available, the following items were selected: vertical jump[16], toe

[16] T. K. Cureton, "Fitness of the Feet and Legs," *Supplement to the Research Quarterly*, **12**: (May, 1941), 368-381.

flexor strength[16], and bounce test.[17] Each of these was modified in an attempt to make the test more valid. In the vertical jump, the depth of the crouch was controlled and the use of the arms eliminated. In the toe flexor strength test, the foot and leg were isolated more completely for testing by re-designing the apparatus used by Cureton. In the bounce test, an attempt was made to improve balance by using straps on the feet which the student could grasp in place of grasping the ankles, and splints on the arms to prevent bending the elbows to relieve the strain on the legs.

TABLE 1

*Test reliabilities and intercorrelations*

| | | VERTICAL JUMP | TOE FLEXOR STRENGTH NORMAL | TOE FLEXOR STRENGTH SUPINATED | RELIABILITY |
|---|---|---|---|---|---|
| | *N* | *r* | *r* | *r* | *r* |
| Vertical jump | 81 | — | — | — | 0.86 |
| Toe flexor strength | | | | | |
| Normal | 81 | 0.10 | — | — | 0.96 |
| Supinated | 81 | 0.08 | 0.72 | — | 0.92 |
| Bounce | 81 | 0.08 | 0.08 | −0.03 | — |

TABLE 2

*Coefficients of correlations between actual metatarsal length and tests*

| | *N* | *r* |
|---|---|---|
| Bounce | 81 | −0.02 |
| Vertical jump | 81 | −0.02 |
| Toe flexor strength | | |
| Normal position | 81 | 0.05 |
| Supinated position | 81 | 0.00 |
| Difference between normal and supinated readings of toe flexor strength | 81 | 0.04 |

TABLE 3

*Coefficients of correlations between actual metatarsal length and physical findings*

| | N | r |
|---|---|---|
| Estimated difference in metatarsal length | 81 | 0.66 |
| Length of toes | 81 | 0.56 |
| Angle of walk | 81 | 0.16 |
| Hallux valgus | 81 | 0.16 |

Pronation was measured by ratings and also by measuring heel cord deflection. Pressure points and angle of walk were measured on footprints.

## Analysis of Data

Three to five readings were taken on each part of the vertical jump and toe flexor strength tests. The number varied with the consistency of the

[17] M. Gladys Scott, Margaret Mordy, and Marjorie Wilson, "Validation of Mass-Type Physical Tests of Work Capacity," *Research Quarterly*, **16**: (May, 1945), 128–139.

TABLE 4

*Comparison of mean metatarsal length* of groups dichotomized on the basis of the presence or absence of certain physical conditions*

| | N† | MEAN | STANDARD DEVIATION | CRITICAL RATIO | LEVEL OF SIGNIFICANCE |
|---|---|---|---|---|---|
| | | | | | % |
| Callouses under second metatarsal | | | | 2.35 | 1 |
| a. Present | 27 | −3.52 | 3.08 | | |
| b. Absent | 52 | −1.81 | 3.05 | | |
| Claw toes | | | | 0.42 | 50 |
| a. Present | 14 | −2.50 | 2.85 | | |
| b. Absent | 61 | −2.14 | 3.07 | | |
| Pain or fatigue | | | | 2.17 | 2 |
| a. Present | 11 | −4.73 | 3.52 | | |
| b. Absent | 57 | −2.30 | 2.65 | | |
| Pressure points under second metatarsal | | | | 12.01 | 0.1 |
| a. Present | 57 | −3.28 | 2.83 | | |
| b. Absent | 22 | −0.36 | 3.10 | | |
| Prominence of first metatarsal cuneiform joint | | | | 3.02 | 0.1 |
| a. Present | 24 | −3.63 | 3.40 | | |
| b. Absent | 48 | −1.60 | 2.18 | | |
| Weight on inside of foot in walking | | | | 1.60 | 7 |
| a. Present | 11 | −4.09 | 3.40 | | |
| b. Absent | 52 | −2.19 | 2.18 | | |
| Pronation rating | | | | 2.38 | 1 |
| a. Present | 22 | −3.59 | 2.76 | | |
| b. Normal | 34 | −1.59 | 3.44 | | |

* Difference between first and second metatarsals measured in millimeters.

† The variation in N is due to discarding of cases about which there was a question or where data were incomplete.

TABLE 5

*Coefficients of correlation between pronation rating, tests, and physical findings*

| | N | r |
|---|---|---|
| Vertical jump | 80 | 0.00 |
| Toe flexor strength—normal | 80 | 0.06 |
| Bounce test | 80 | 0.03 |
| Scaphoid measurement | | |
| Right foot | 61 | 0.46 |
| Left foot | 59 | 0.46 |
| Malleolus measurement | | |
| Right foot | 61 | 0.46 |
| Left food | 59 | 0.43 |
| Heel cord deflection | 79 | 0.43 |
| Angle of walk | | |
| Right foot | 80 | 0.02 |
| Left foot | 80 | 0.03 |
| Rating of right and left feet | 80 | 0.88 |

performer. Coefficients of reliability were computed by correlating the scores on the last trial with the median score for all the trials.

None of the measures of foot function correlate with shortness of the first metatarsal and all have low intercorrelations. However, as they have been found to be valid tests of foot strength, power and endurance by other investigations, it is probable that there is little or no relation between relative length of metatarsals and foot function as measured by these tests, at least as far as this population of college women is concerned.

If additional study were to be done on this topic, it would be convenient if subjects could be selected by an examination of the foot without x-rays. However, the coefficient of correlation between the original estimate and x-ray findings in this study is too low to make such a recommendation. Digital length has been suggested as a method of screening subjects for shortness of the first metatarsal. The coefficient of correlation between the actual metatarsal length as measured on the x-ray and the toe length was not high enough to make it a valid diagnostic sign.

Although the number complaining of pain was small, the number increased directly with the increase in degree of metatarsal shortness.

## Conclusions

1. Apparently, there is little significant relationship between shortness of the first metatarsal and foot function of young adult women of college age.
2. External examination alone is not a valid test for determining metatarsal shortness.
3. Digital length, while related, is not a significantly valid criterion to be used for prediction of metatarsal length in individuals.
4. Angle of walk and hallux valgus are only very slightly related to shortness of the first metatarsal.
5. Presence of callous and pressure under the head of the second metatarsal as shown on the footprints or examination are highly significant in relation to shortness of the first metatarsal.
6. Prominence of the first metatarsal cuneiform joint is also very closely related to shortness of the first metatarsal.
7. Pronation as determined by a rating appears to be definitely related to shortness of the first metatarsal, but does not appear to be related to the tests of foot function used in this study.
8. Carrying the weight on the inside of the foot in walking and prominence of the scaphoid and medial malleolus appear to be definitely related to pronation as determined by rating.
9. Heel cord deflection, while it offers possibilities for further study as an objective test of pronation, is not a valid measure as administered in this test.
10. Angulation of the patella, apparently, is not a good indication of pronation.
11. Pain and fatigue seem to be more prevalent among those with short first metatarsals.

## Suggestions for Further Study

1. Measurement of hypertrophy of the cortex of the metatarsals to determine its relationship to shortness of the first metatarsal at this age.
2. Further study of individuals with shortness of the first metatarsal with x-ray photographs taken from the medial side of the foot in a horizontal plane to determine the part played by the sesamoids in compensating for shortness of the first metatarsal.
3. Study and refinement of the scales of scaphoid and malleolus prominence and their relation to pronation.
4. Study of heel cord deflection with view to improving accuracy in judging the center line of the tendon of Achilles.
5. Study of the walk of individuals of known metatarsal length by means of movies to determine the relationship of metatarsal length to rotation at the hip joint.
6. Study of the walk of individuals of known metatarsal length by means of movies to analyze the use of the foot in the push off phase of locomotion.
7. Repetition of studies of foot function in relation to shortness of the first metatarsal in an older age range.

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# Status of Statutory Health Instruction in the United States

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TO WHAT extent is health instruction in the elementary and/or secondary schools of the several states and the District of Columbia required by statute? To what extent is the teaching of various areas of health required? In an effort to secure data bearing on these questions and others, a letter of inquiry was sent during the school-year 1948–1949 to the chief educational officers of the several states and the District of Columbia. Forty-two replies were received from the forty-nine inquiries, a return of approximately eighty-six per cent. Data concerning the seven states not replying were secured from other sources that were deemed valid (1, 2).

Answers to four questions were sought in the above-mentioned letter of inquiry. The questions asked were:

1. Is health instruction (not physical education) *required by statute* in your state? If so, at what level or levels?
2. Does your statute specify a title for the required course in health? If so, what is that title?
3. Does your statute require that a course of study be developed? If so, by whom? For what levels?
4. In what areas (effects of alcohol; safety; etc.) is health instruction required by your statute?

Data bearing on question one above are given in detail in column two, Table 1. Attention is directed to the fact that thirty-two states replied that they had some type of health instruction required by statute. However, Idaho, Maryland, Missouri, Nebraska, and New Hampshire in replying to question one indicated they did not have any statute requiring health instruction, although, in replying to question four, they indicated that at least one area was required by statute. It would seem, therefore, that the statutes of thirty-seven states actually did require that some type of health instruction be given in their elementary and/or secondary schools.

Health instruction was required in grades one through twelve by twenty-five states; in grades one through eight by four states; while grade-ranges of one through nine, one through ten, and nine through twelve were indicated by one state each. In other words, of the thirty-seven states indicating that some type of health instruction was required by statute, approximately sixty-seven per cent specified such instruction must be given in all elementary and secondary grades.

TABLE 1

*State statutory requirements for health instruction*

| STATE | INSTRUCTION REQUIRED | TITLE SPECIFIED | COURSE OF STUDY REQUIRED (Authority) | AREAS IN WHICH HEALTH INSTRUCTION IS REQUIRED BY STATUTE |
|---|---|---|---|---|
| | *Grades* | | | |
| Alabama | 1–12 | Hygiene and Sanitation | no | Hygiene and sanitation. Alcohol; tobacco; narcotics |
| Arizona | none | none | no | None |
| Arkansas* | 1–12 | none | no | Part of Physical Education |
| California | 1–12 | none | no | Alcohol, narcotics; safety |
| Colorado | 1–12 | none | no | Alcohol; narcotics required in all grades |
| Connecticut | 1–12 | none | Com. of Education | Safety, all levels. Alcohol third grade and above |
| Delaware† | none | none | no | None |
| Florida* | none | none | no | None |
| Georgia | none | none | no | None |
| Idaho‡ | none | none | no | Alcohol, narcotics required |
| Illinois | 1–9 | Physiology and Hygiene | no | Safety; alcohol, narcotics |
| Indiana | 9–12 | Health and Safety | State Bd. for H. S. | Alcohol; nutrition |
| Iowa | 1–12 | none | State Supt. of Education | Alcohol, narcotics, poisonous substances |
| Kansas | 1–12 | Health and Hygiene | State Supt. of Education | Alcohol. Other areas general |
| Kentucky | 1–10 | Basic Health | H. S. State Safety Bd. | Other areas general |
| Louisiana | 1–8 | none | Local Board | Alcohol, narcotics in 1–8 |
| Maine | 1–12 | none | Indirect Com. of Educ. | Personal hygiene; community sanitation; safety |
| Maryland‡ | none | none | no | Alcohol, narcotics required by old state law |
| Massachusetts | 1–12 | Physiology and Hygiene | no | Alcohol and narcotics; tuberculosis |
| Michigan | none | none | no | None |
| Minnesota | 1–12 | none | Comm. Ed. to Supv. of P.E. | Alcohol and narcotics; morals |
| Mississippi | 1–12 | none | no | Narcotics; safety |
| Missouri‡ | none | none | no | Alcohol though not specified as to grade |
| Montana† | 1–12 | none | no | General areas |
| Nebraska‡ | none | none | no | Attention to alcohol and narcotics required |
| Nevada | 1–12 | Physiology and Hygiene | no | Alcohol and narcotics |
| New Hampshire‡ | none | none | no | Alcohol and narcotics required by old law |
| New Jersey | 1–12 | none | State Dept. or Local Bd. | Safety; first aid; home nursing; alcohol and narcotics |
| New Mexico | none | none | no | None |
| New York | 1–12 | Health Teaching | State Dept. of Education | Mental health; nutrition; personal hygiene; dental health; first aid; safety; disease prevention; Alcohol and narcotics |

TABLE 1—*Continued*

| STATE | INSTRUCTION REQUIRED | TITLE SPECIFIED | COURSE OF STUDY REQUIRED (Authority) | AREAS IN WHICH HEALTH INSTRUCTION IS REQUIRED BY STATUTE |
|---|---|---|---|---|
| | *Grades* | | | |
| North Carolina | 1–8 | none | State Supt. Ed. | Safety; alcohol and narcotics |
| North Dakota | 1–8 | none | State Bd. Education | Safety; alcohol |
| Ohio | none | none | no | none |
| Oklahoma | 1–12 | none | no | Law passed, no appropriation made |
| Oregon | 1–12 | none | Supt. of Public Instruction. | Structure-function; first aid; safety; personal hygiene; communicable disease; selection services; alcohol-narcotics; mental hygiene; physiology of exercise; health and sanitation; nutrition |
| Pennsylvania | 1–12 | Health Education | Chief of Health P.E. | Safety; alcohol |
| Rhode Island | none | none | no | none |
| South Carolina | 1–8 | none | no | Safety |
| South Dakota | none | none | no | none |
| Tennessee† | none | none | no | none |
| Texas | 1–12 | Physiology Hygiene | State Supt. Education | Alcohol and narcotics |
| Utah | 1–12 | Physiology Hygiene | State Bd. of Education | Sanitation; communicable diseases; alcohol and narcotics |
| Vermont | 1–12 | none | no | Alcohol and narcotics |
| Virginia | 1–12 | none | State Ed. | Safety; Alcohol, narcotics |
| Washington | 1–12 | Physiology Hygiene | no | Effects of exercise; Alcohol and narcotics |
| West Virginia | 1–12 | none | no | Alcohol and narcotics |
| Wisconsin* | none | none | no | none |
| Wyoming | 1–12 | none | no | Alcohol and narcotics |
| District of Columbia* | none | none | no | none |

* No reply. Data taken from F. S. Stafford, *State Administration of School Health, Physical Education and Recreation.* Office of Education, Bulletin 1947, No.13, 1947.
† No reply. Data taken from mimeographed report of Committee on Legislation. Society of State Directors of Health and Physical Education, April 1, 1946.
‡ Reported no statute; however, reported alcohol one area required taught.

Replies to question two (as tabulated in column three, Table 1) revealed that four states specified the title, Physiology and Hygiene, for their required program of health instruction. Seven other states indicated seven different titles. Frequently the laws seemed to mean that instruction was to be given in the field of hygiene, physiology, or health without intending that those terms should constitute the title of the required program of health instruction.

The development of a course of study for the health instruction program was required by statute in seventeen states. The state board of education and the chief educational officer of the state were the two sources most frequently held responsible for developing that course of study, the former in seven states, and the latter in eight states. One state placed the responsibility with the local board of education and one state with the state health and physical education officer. Column four, Table 1, gives the tabulated data relative to that question.

Replies to question four (as tabulated in column five, Table 1) indicated that only two or three areas of health were consistently specified by statute in the several states. The area of alcohol, stimulants, and narcotics (as they effect the human body) was the area most frequently mentioned, thirty-one states having such statutory requirement. Instruction in safety was required in fourteen states. Four states required instruction in the area of sanitation. Three states required instruction in nutrition. Two states required instruction in the area of communicable diseases. Other areas reported were too general in nature or mentioned by only one state as being required by statute.

Based on conditions existing at the time of this study (1948) it can be said in summarization that:

1. Seventy-five per cent of the states required by statute that health instruction be given in the elementary and/or secondary grades.

2. Of the states requiring health instruction by statutory act, sixty-seven per cent required that such instruction be given in grades one through twelve, eleven per cent grades one through eight, three per cent grades one through ten, three per cent grades one through nine, three per cent grades nine through twelve, while thirteen per cent did not specify any particular grade-range.

3. Specification of title by statute was not generally engaged in as evidenced by the fact that only twelve states made such provision.

4. Approximately thirty-four per cent of the states made statutory provision for the development of a course of study for the health instruction program. Responsibility for the development of that course of study was primarily lodged with either the state board of education or the chief state educational officer, seven states indicating the former and eight states the latter.

5. Better than sixty-three per cent of the states required by statute that instruction be given in the effects of alcohol, stimulants, and narcotics on the human body.

6. Safety instruction was required by statute in approximately twenty-eight per cent of the states.

7. Less than eight per cent of the states required by statute that instruction be given in sanitation.

8. Only six per cent of the states required by statute that nutrition be taught.

9. The teaching of communicable diseases was required by statute in four per cent of the states.

10. Only one state required by statute that some instruction be given relative to the effects of tobacco on the human body.

11. Areas reported by one state each were; poisonous substances, tuberculosis, home nursing, dental health, first aid, disease prevention, structure and function of the human body, selection and use of health services and health products, physiological effects of exercise on the human body, mental hygiene, and community health.

12. Oregon, with eleven areas specified, led all other states in the total number of areas in which health instruction was required by statute.

In conclusion mention should be made of the fact that no attempt was made to ascertain the extent of health instruction being required in the several states and the District of Columbia by means of rules and regulations. It was believed that such requirements were of a more transitory nature and would probably present more of a shifting picture than statutory requirements would present.

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# The Status of Boxing in Institutions of Higher Learning

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THE PLACE of boxing in educational programs is a controversial issue not only among physical educators but also among educators in general. In 1940 Kenney and his associates instigated this controversy by focusing the attention of others upon it through the results of an evaluation of boxing as a college activity (3). The problem still continues.

Basic to a study and evaluation of boxing in colleges and universities lies the need for a composite picture of current practice and opinion relating to boxing—the status of boxing in institutions of higher learning (4).[1] To fulfill this need questionnaries were submitted to 794 institutions of higher learning enrolling men in the United States. Each institution received two questionnaires; one for the person directly responsible for physical education for men, and another for the director of health services. The questionnaire intended for physical education administrators dealt with facts concerning current practice and opinion relating to boxing. The document directed to health service administrators was designed to ascertain the prevalence of significant injuries in boxing as well as opinion about the activity.

## Findings

The findings of this questionnaire study comprised a 78 per cent response; 620 of 794 institutions having replied. During the academic year 1948–49, as indicated by the replies, 263 institutions offered boxing in one or more of the following: physical education class program; intramural program; and intercollegiate program. Boxing was conducted in these programs by 228, 123 and 59 schools, respectively. The number of institutions offering boxing during 1948–49 included 143 under public control, 56 private colleges and universities, and 64 denominational schools. In lieu of intercollegiate competition three colleges sponsored participation in Golden Gloves tournaments, and one school enabled students to enter Amateur Athletic Union competition.

[1] The data presented herein comprised an integral part of "An Evaluation of Boxing as a Sports Activity in Institutions of Higher Learning," a study approved for sanction by the Executive Council of the College Physical Education Association in March 1949.

Table 1 discloses the extent to which boxing was sponsored by responding institutions both during 1948–49 and within the past decade (beginning with the academic year 1939–40). As shown by this table, 62 colleges and universities had sponsored the activity in one or more of the forementioned programs within the past decade but have subsequently discontinued all boxing. During this period an additional 50 schools have dispensed with the activity in part. Lack of a qualified instructor, limited facilities and equipment, and little student interest accounted for 59, 52 and 40 per cent of the discontinuance of boxing from physical education class, intramural and intercollegiate programs, respectively. It was noted that the majority of reasons given by respondents for dropping boxing may be categorized as complicating factors attributable to the nature of the activity. For example, the recommendations of professional organizations and administrative difficulties, two of the reasons mentioned by respondents, may be

TABLE 1

*Boxing in colleges and universities*

| | PHYSICAL EDUCATION CLASS PROGRAM | | INTRAMURAL PROGRAM | | INTER-COLLEGIATE PROGRAM | | TOTAL REPORTING | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Institutions sponsoring boxing, 1948–49 | 228 | 36.8 | 123 | 19.8 | 59 | 9.5 | 263 | 42.4 |
| Institutions dropped boxing in past decade | 48 | 7.7 | 54 | 8.7 | 41 | 6.6 | 62* | 10.0 |
| Institutions without any boxing in past decade | 344 | 55.5 | 443 | 71.5 | 520 | 63.9 | 295 | 47.6 |
| Total | 620 | 100.0 | 620 | 100.0 | 620 | 100.0 | 620 | 100.0 |

* This figure includes only those institutions that have discontinued all boxing.

classified as complicating factors accruing from the nature of the activity.

During 1948–49 a mean of 150 students received instruction in the physical education class programs of 200 institutions, which furnished such statistics. The number ranged from 9 to 2500 students. For the same period 95 schools reported a mean of 64 participants in a range from 12 to 300 for boxing in intramural programs. The average number of contestants in the intercollegiate boxing programs of 54 institutions was 27; the range being from 6 to 80.

Boxing instruction in the physical education class program was offered in the majority of institutions as an elective during 1948–49. Table 2 shows the various ways in which boxing instruction was given with the frequencies of occurrence.

Table 3 reveals the tabulated response to an inquiry as to the safety measures used for boxing during 1948–49 in the physical education class program, and for competition and practice in intramural and intercollegiate

programs. The tabulation may appear to indicate that relatively few institutions utilized any precautionary measures. Obviously, the recorded response reflects the frequency of mention accorded to the various measures which were deemed to be most important by respondents. Some replies listed only one item, e.g., close supervision, whereas others were more definitive and delineated equipment and other controls. For the intercollegiate program one-third of the reporting institutions designated compliance with regulations of the National Collegiate Athletic Association. Conformance to these regulations insures provision of other specific items enumerated in the tabulation; such as hand wraps, groin protection, padded floor, medical examination before bouts, and presence of a physician at contests.

Relative to the prevalence of significant injuries in boxing, respondents were requested to furnish available facts concerning such injuries and their incidence as sustained during the past decade in all forms of boxing conducted by their respective institutions. Table 4 discloses the reply to a query as to serious cases of physical or mental impairment that were directly traceable to participation in boxing at reporting institutions within the past decade. Table 5 contains a tabulation of the response from the 325 institutions that have sponsored boxing regarding other significant health disturbances directly traceable to participation in boxing since 1939. In these two tables the response of medical doctors (M.D.) serving as health service directors has been differentiated from persons not trained as physicians (Not M.D.). Also, injuries incurred at institutions sponsoring boxing only in the physical education class program have been segregated from those sustained at institutions which conducted competitive boxing in intramural or intercollegiate programs.

TABLE 2

*Boxing instruction in physical education class programs during 1948–49*

| OFFERED AS* | INSTITUTIONS | |
|---|---|---|
| | No. | % |
| Requirement (including requirement reported for teacher training programs in physical education only) | 87 | 35.8 |
| | (19) | (7.8) |
| Elective | 103 | 42.4 |
| Elective to meet a requirement in general area of combative activities | 37 | 15.2 |
| Not specified | 16 | 6.6 |
| Total | 243 | 100.0 |

* Instruction was offered by 11 institutions in two of these ways, and by two schools in all of the possibilities.

The incidence of injury in boxing at institutions of higher learning was computed from the number of participants, injuries and knockouts for both the academic year 1948–49 and the preceding nine years of the past

TABLE 3

*Safety measures employed for boxing in 1948–49*

| SAFETY MEASURE REPORTED | NUMBER OF INSTITUTIONS | | | | |
|---|---|---|---|---|---|
| | Physical education class program | Intramural program | | Intercollegiate program | |
| | | Competition | Practice | Competition | Practice |
| Head guards | 122 | 57 | 47 | 13 | 43 |
| Head guards—optional | 4 | | 2 | | |
| Head guards with face masks | 7 | 1 | 2 | | 2 |
| Head guards with face masks—optional | 2 | | 1 | | 1 |
| No head guards | 3 | 1 | | | |
| Teeth protectors | 54 | 29 | 20 | 5 | 20 |
| Groin protectors (cups) | 12 | 12 | 8 | 1 | 2 |
| Abdominal protectors | 2 | 1 | | | |
| Hand wraps | 19 | 9 | 5 | 5 | 10 |
| Vaseline | 1 | 3 | 2 | 1 | 2 |
| Heavy gloves | 21 | 5 | 9 | | 5 |
| 18 ounce gloves | 1 | | | | |
| 16 ounce gloves | 49 | 15 | 11 | 2 | 11 |
| 14 and 16 ounce gloves | 4 | | 1 | 1 | 1 |
| 14 ounce gloves | 16 | 9 | 2 | 1 | 5 |
| 12 ounce gloves | 1 | 3 | | | 1 |
| Gloves according to weight classes | 1 | 1 | | | |
| Good equipment | | | | | 2 |
| Padded floor | 19 | 7 | 2 | 3 | 3 |
| Regulation ring | 5 | 4 | | | |
| Thorough medical examination | 9 | 14 | | | 1 |
| Medical examination before bouts | | 1 | | | |
| Adequate instruction | 16 | 2 | 2 | | |
| Conditioning | 13 | 8 | 4 | 2 | 5 |
| Close supervision | 35 | 11 | 30 | 2 | 13 |
| Stress fundamentals, controlled sparring | 4 | | | | 1 |
| No competition | 8 | | | | |
| Proper weight matching | 10 | | | | 2 |
| Even competition—matching according to ability and weight | 5 | 1 | 3 | 2 | |
| Only conditioning | | | 1 | | |
| Presence of a physician | | 48 | 1 | 1 | |
| Presence of a trainer | | 4 | 3 | | 1 |
| Competent officials | | 6 | | 1 | |
| Comply with NCAA rules | | 1 | | 17 | 24 |
| Follow AAU rules | | | | 2 | |
| College rules | | 1 | | | |
| Shortened rounds | 6 | 8 | 5 | | |
| 1 minute rounds | 1 | 1 | | | |
| Bouts of 2 rounds | | 6 | | | |
| Knockdown ends round | | 2 | | | |
| Special knockdown rule | 1 | 1 | | | |
| Fast count refereeing | 1 | 1 | | | |
| Referee stops bouts early in uneven matches or upon signs of injury | | 1 | | | |
| Stopping over-match before official | | | | 1 | |
| All necessary precautions | 4 | 5 | 2 | 2 | |
| None | 10 | 1 | 1 | | |

decade. Since these statistics were not readily available at many institutions, the injury incidence presented in Tables 6 and 7 is based on 120 institutions

TABLE 4

*Serious cases of impairment attributable to boxing in the past decade*

| CASE REPORTED | NUMBER OF CASES | | | | | | |
|---|---|---|---|---|---|---|---|
| | Class program only | | With Competitive boxing | | Total | | |
| | Not M.D. | M.D. | Not M.D. | M.D. | Not M.D. | M.D. | Both |
| Brain concussion | | | 2 | 17 | 2 | 17 | 19 |
| Dementia pugilistica (punchdrunkness) | | | 1 | 4 | 1 | 4 | 5 |
| Amnesia | | | 3 | 2 | 3 | 2 | 5 |
| Intracranial hemorrhage | | | 1* | 3† | 1 | 3 | 4 |
| Signs of mild dementia pugilistica | 1 | | 2 | | 3 | | 3 |
| Serious head injury | | | | 1 | | 1 | 1 |
| General paralysis of right side and right extremities | | | | 1 | | 1 | 1 |
| Paralysis of motor occular nerve | | | 1 | | 1 | | 1 |

* Outcome was fatal.

† Outcome was fatal in one case; motor aphasia and epileptiform seizures in another.

TABLE 5

*Significant health disturbances directly traceable to boxing in the past decade*

| CASE REPORTED | NUMBER OF CASES | | | | | | |
|---|---|---|---|---|---|---|---|
| | Class program only | | With competitive boxing | | Total | | |
| | Not M.D. | M.D. | Not M.D. | M.D. | Not M.D. | M.D. | Both |
| Cuts over eye | 5 | | 18 | 17 | 23 | 17 | 40 |
| Broken tooth | 2 | | 8 | 22 | 10 | 22 | 32 |
| Dislocated shoulder | 1 | | 21 | | 22 | | 22 |
| Fractured hands | | | | 13 | | 13 | 13 |
| Serious nose injury (surgical correction) | | | 1 | 12 | 1 | 12 | 13 |
| Ruptured tympanic membrane | | | 3 | 5 | 3 | 5 | 8 |
| Fractured nose | | | 3 | 1 | 3 | 1 | 4 |
| Persistent headache | | | 1 | 2 | 1 | 2 | 3 |
| Sprained ankle | 3 | | | | 3 | | 3 |
| Kidney injury | 1 | | | | 1 | | 1 |
| Subcute auricular perichrondritis (cauliflower ear) | | | | 1 | | 1 | 1 |
| Hernia | | | 1 | | 1 | | 1 |
| Nose injury | | | 1 | | 1 | | 1 |
| Fractured jaw | | | 1 | | 1 | | 1 |
| Fractured rib | | | | 1 | | 1 | 1 |
| Fractured tibia and fibula | | | 1 | | 1 | | 1 |
| Dislocated patella | | | 1 | | 1 | | 1 |

for 1948–49 and 72 schools for the academic years 1939–40 through 1947–48. The accuracy of reported figures remains speculative. For most institutions it is undetermined whether the statistics were secured from actual records or derived by conjecture. Although knockouts are usually regarded as in-

juries by the medical profession, they are distinguished from other injuries in the tables to facilitate comparison of the incidence of generally recognized injuries with previous researches (1, 2). The incidence of injury and knockouts at reporting institutions showed an increase for the academic year 1948–49 over the incidence of injury and knockouts for the academic years 1939–40 through 1947–48. This increase apparently occurred despite alleged emphasis to reduce the hazardousness of the activity, although the possible inaccuracy of reported figures, for academic years prior to 1948–49 in particular, must be recognized.

A section designed to ascertain opinion about the place of boxing in institutions of higher learning was included in both questionnaires. This

TABLE 6

*Incidence of injury in boxing during academic year 1948–49*

| PROGRAM | NUMBER OF PARTICIPANTS | INJURIES | | KNOCKOUTS | | NUMBER OF INSTITUTIONS |
|---|---|---|---|---|---|---|
| | | No. | % | No. | % | |
| Physical education class program only | 2477 | 7 | 0.3 | 8 | 0.3 | 34 |
| Including competitive boxing | 7058 | 89 | 1.3 | 179 | 2.6 | 86 |
| Total | 9535 | 96 | 1.0 | 187 | 2.0 | 120 |

TABLE 7

*Incidence of injury in boxing during academic years commencing 1939 and ending 1948*

| PROGRAM | NUMBER OF PARTICIPANTS | INJURIES | | KNOCKOUTS | | TOTAL NUMBER OF YEARS | NUMBER OF INSTITUTIONS | MEAN YEARS |
|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | | | |
| Physical education class program only | 6860 | 9 | 0.1 | 24 | 0.4 | 111 | 22 | 5.0 |
| Including competitive boxing | 22562 | 178 | 0.8 | 424 | 1.9 | 269 | 50 | 5.4 |
| Total | 29422 | 187 | 0.6 | 448 | 1.5 | 380 | 72 | 5.4 |

opinion part consisted primarily of statements to which respondents were requested to indicate their judgment by either checking: (+) yes or approval; (−) no or disapproval; or (?) preference being not to express an opinion.

The general response elicited by statements on the questionnaire directed to physical education administrators is recorded in Table 8. Therein the opinion of individuals representing institutions that have had no boxing in the past decade is segregated from the beliefs of persons responsible for physical education for men at institutions that have had boxing during the past decade. The assumption underlying this differentiation is that more reliability can be affixed to opinion based upon experience with the activity than to opinion which is not founded upon experience. However,

it is recognized that some representatives of institutions which have not sponsored boxing of late may have had experience with the activity elsewhere.

In over-all perspective the opinion of physical education administrators was favorable toward boxing. However, opinion concerning intercollegiate boxing was not decisive; the deciding vote lay in the group that was doubtful. It was noted that 49 per cent of the respondents representing institutions that have sponsored some boxing felt the need for more stringent

TABLE 8

*Prevalent opinion of physical educators about boxing*

| | NUMBER OF INSTITUTIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No boxing | | | With boxing | | | Total | | |
| | + | − | ? | + | − | ? | + | − | ? |
| Desirability of the following: | | | | | | | | | |
| Boxing instruction in physical education class program | 94 | 56 | 16 | 255 | 28 | 9 | 349 | 84 | 25 |
| Competitive boxing in intramural program | 71 | 81 | 16 | 159 | 104 | 24 | 230 | 185 | 40 |
| Intercollegiate boxing | 71 | 77 | 16 | 128 | 109 | 43 | 199 | 186 | 59 |
| Boxing can or cannot be controlled so that it warrants inclusion as an activity in: | | | | | | | | | |
| Physical education class program | 103 | 47 | 14 | 257 | 27 | 10 | 360 | 74 | 24 |
| Intramural program | 84 | 65 | 17 | 169 | 94 | 23 | 253 | 159 | 40 |
| Intercollegiate program | 80 | 66 | 19 | 136 | 100 | 48 | 216 | 166 | 67 |
| Suitability of the following: | | | | | | | | | |
| More stringent controls over competitive boxing than those of NCAA | 57 | 19 | 70 | 131 | 53 | 87 | 188 | 72 | 157 |
| Mandatory use of headgear *without* face mask in all competitive contests | 81 | 24 | 41 | 154 | 58 | 48 | 235 | 82 | 89 |
| Mandatory use of headgear *with* face mask in all competitive contests | 39 | 52 | 50 | 85 | 106 | 59 | 124 | 158 | 109 |
| Required presence of a physician at all contests | 113 | 13 | 27 | 236 | 14 | 27 | 349 | 27 | 54 |
| Validity of the following: | | | | | | | | | |
| Boxing offers a unique type of educational experience not to be found in any other physical education activity | 64 | 75 | 32 | 167 | 85 | 36 | 231 | 160 | 68 |
| Educational benefits generally credited to boxing can be derived from other sports activities without the dangers present in boxing | 106 | 33 | 31 | 125 | 108 | 58 | 231 | 141 | 89 |
| If weight of scientific evidence should indicate that competitive boxing presents an unwarranted risk to participants, the educational value would still justify teaching boxing in class program | 39 | 109 | 29 | 98 | 157 | 33 | 137 | 266 | 62 |

controls over competitive boxing than the regulations specified by the National Collegiate Athletic Association. Thirty-two per cent of these individuals were undecided on the desirability of more stringent controls.

The opinion elicited by statements on the questionnaire submitted to health service directors is recorded in Table 9. As in Table 8, the response is divided into representatives of institutions that have not sponsored boxing within the past decade and directors at schools which have conducted boxing since 1939. Similarly, Table 10 delineates the opinion of

TABLE 9

*Prevalent opinion of health service directors about boxing*

| | NUMBER OF INSTITUTIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No boxing | | | With boxing | | | Total | | |
| | + | − | ? | + | − | ? | + | − | ? |
| As commonly conducted, is boxing sufficiently safe and appropriate for college men in: | | | | | | | | | |
| Physical education class program | 85 | 59 | 16 | 196 | 42 | 9 | 281 | 101 | 25 |
| Intramural program | 72 | 66 | 23 | 141 | 79 | 26 | 213 | 145 | 49 |
| Intercollegiate program | 70 | 60 | 28 | 117 | 82 | 42 | 187 | 142 | 70 |
| Mandatory use of headgear *without* face mask in: | | | | | | | | | |
| Physical education class participation | 84 | 37 | 22 | 149 | 58 | 24 | 233 | 95 | 46 |
| Intramural competition | 83 | 32 | 23 | 139 | 50 | 30 | 222 | 82 | 53 |
| Intercollegiate competition | 53 | 42 | 37 | 99 | 74 | 42 | 152 | 116 | 79 |
| Intramural and intercollegiate practice sessions | 84 | 28 | 26 | 155 | 27 | 30 | 239 | 55 | 56 |
| Mandatory use of headgear *with* face mask in: | | | | | | | | | |
| Physical education class participation | 64 | 50 | 29 | 91 | 100 | 33 | 155 | 150 | 62 |
| Intramural competition | 47 | 54 | 35 | 72 | 98 | 43 | 119 | 152 | 78 |
| Intercollegiate competition | 30 | 65 | 39 | 43 | 117 | 43 | 73 | 182 | 82 |
| Intramural and intercollegiate practice sessions | 54 | 47 | 34 | 76 | 89 | 42 | 130 | 136 | 76 |
| With control measures indicated above or written in is boxing sufficiently safe and appropriate for college men in: | | | | | | | | | |
| Physical education class program | 110 | 28 | 17 | 216 | 21 | 11 | 326 | 49 | 28 |
| Intramural program | 95 | 36 | 23 | 160 | 49 | 24 | 255 | 85 | 47 |
| Intercollegiate program | 84 | 42 | 25 | 130 | 66 | 35 | 214 | 108 | 60 |

TABLE 10

*Prevalent opinion of medical doctors serving as health service directors about boxing*

| | NUMBER OF INSTITUTIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No boxing | | | With boxing | | | Total | | |
| | + | − | ? | + | − | ? | + | − | ? |
| As commonly conducted, is boxing sufficiently safe and appropriate for college men in: | | | | | | | | | |
| Physical education class program | 12 | 9 | 2 | 47 | 14 | | 59 | 23 | 2 |
| Intramural program | 9 | 10 | 3 | 34 | 22 | 4 | 43 | 32 | 7 |
| Intercollegiate program | 7 | 10 | 5 | 24 | 32 | 6 | 31 | 42 | 11 |
| Mandatory use of headgear *without* face mask in: | | | | | | | | | |
| Physical education class participation | 12 | 3 | 2 | 38 | 13 | 6 | 50 | 16 | 8 |
| Intramural competition | 11 | 2 | 3 | 36 | 11 | 9 | 47 | 13 | 12 |
| Intercollegiate competition | 5 | 5 | 4 | 26 | 15 | 11 | 31 | 20 | 15 |
| Intramural and intercollegiate practice sessions | 9 | 3 | 3 | 36 | 8 | 11 | 45 | 11 | 14 |
| Mandatory use of headgear *with* face mask in: | | | | | | | | | |
| Physical education class participation | 10 | 10 | 1 | 21 | 25 | 8 | 31 | 35 | 9 |
| Intramural competition | 8 | 6 | 3 | 19 | 19 | 12 | 27 | 25 | 15 |
| Intercollegiate competition | 7 | 5 | 4 | 16 | 21 | 12 | 23 | 26 | 16 |
| Intramural and intercollegiate practice sessions | 9 | 6 | 3 | 21 | 18 | 11 | 30 | 24 | 14 |
| With control measures indicated above or written in is boxing sufficiently safe and appropriate for college men in: | | | | | | | | | |
| Physical education class program | 14 | 4 | 3 | 34 | 10 | | 48 | 14 | 3 |
| Intramural program | 10 | 6 | 4 | 38 | 21 | 3 | 48 | 27 | 7 |
| Intercollegiate program | 7 | 9 | 4 | 17 | 27 | 6 | 24 | 36 | 10 |

TABLE 11

*General comments of physical educators about boxing*

| COMMENT | NUMBER OF INSTITUTIONS | | |
|---|---|---|---|
| | No boxing | With boxing | Total |
| Eliminate competitive boxing | 5 | 24 | 29 |
| Since: | | | |
| It cannot be controlled | 2 | 5 | 7 |
| Nature of sport is such that it cannot be controlled by rule or equipment to offset major hazard—head injuries | | 2 | 2 |
| Cannot control matching; too much emphasis on winning | | 2 | 2 |
| Boxing is too dangerous above physical education classes due to intensity | | 4 | 4 |
| Nature of the activity is not educationally sound; objective of boxing is not reconcilable as an objective of education | 2 | 7 | 9 |
| Limit boxing to class instruction as a phase of safety skill development | 1 | 3 | 4 |
| An anti-social sport promoted among those needing socializing team games | | 1 | 1 |
| Eliminate boxing | 4 | 6 | 10 |
| Since: | | | |
| Success depends upon ability to injure | 2 | 3 | 5 |
| Possibility of head injury overshadows any educational advantages not covered by other sports | 1 | 1 | 2 |
| Continuous hitting on head is bound to leave detrimental results | | 1 | 1 |
| Evidence indicates it is undesirable | 1 | | 1 |
| Recommendations of professional organizations cited as basis for elimination of boxing | | 1 | 1 |
| Non-controllable effects of spectators on participants ruin competitive boxing | | 5 | 5 |
| Boxing can be a valuable, wholesome educative experience, if controlled | | 4 | 4 |
| Boxing is a good sport and can be controlled | | 3 | 3 |
| Skeptical that boxing instruction is dangerous | | 3 | 3 |
| Boxing is a good sport offering variety, nothing unique | 1 | 2 | 3 |
| Success of competitive boxing is dependent upon proper financial support and supervision | 1 | 2 | 3 |
| Competitive boxing would be acceptable with scoring system which de-emphasized hard blows and stressed "hit and get away" principle | 2 | 1 | 3 |
| No other sport teaches the valuable lessons of boxing | | 2 | 2 |
| Boxing in class and intramural programs is good if controlled | | 2 | 2 |
| Boxing instruction is desirable in physical education class program as part of general education | | 2 | 2 |
| No evidence exists that competitive boxing is harmful under NCAA rules; research evidence is needed | 1 | 1 | 2 |
| Approve of boxing with: | | | |
| Head guards and face masks | 1 | | 1 |
| Long training period in defense | | 1 | 1 |
| Complete record of internal and head injuries | | 1 | 1 |
| No place for boxing as now promoted by many institutions | | 1 | 1 |
| Wrestling is a better self-defense, combative activity | | 1 | 1 |
| Boxing affords competition for the small boy | | 1 | 1 |
| Those desirous of boxing should be allowed to box | | 1 | 1 |
| Need boxing in our educational programs; too many boys are becoming "soft" | | 1 | 1 |
| Headgear defeats purpose of boxing; makes for careless defense | | 1 | 1 |
| Biggest problem in competitive boxing is matching according to ability | 1 | | 1 |
| See neither much danger in boxing nor reason for promoting it unduly | 1 | | 1 |
| Studies of possible permanent injury indicate that boxing must be carefully controlled | 1 | | 1 |
| Boxing is not administratively feasible; too expensive, dangerous, and impractical | 1 | | 1 |

medical doctors serving as health service directors at institutions which have or have not conducted boxing recently. While the viewpoints of medical doctors are included in Table 9, these beliefs are presented separately in Table 10 in view of the specialized training and interest in the maintenance of health which characterize their proponents.

As in the case of physical educators, the opinion of health service directors was generally favorable toward boxing. The majority deemed boxing sufficiently safe and appropriate for college men. However, the percentage of approval was greater for instructional boxing than for competitive boxing. It was noted that the plurality of all medical doctors and of those serv-

TABLE 12

*Additional safety measures deemed necessary by health service directors for intercollegiate competition*

| SAFETY MEASURE | NUMBER OF INSTITUTIONS | | | |
|---|---|---|---|---|
| | No boxing | With boxing | | Total |
| | | Not M.D. | M.D. | |
| Close supervision | 15 | 12 | 6 | 33 |
| Proper conditioning for participants | 7 | 11 | 3 | 21 |
| Adequate instruction | 8 | 8 | 2 | 18 |
| Complete medical examination | 4 | 9 | 5 | 18 |
| Proper matching (including ability) | 1 | 6 | 2 | 9 |
| Sufficient floor padding | 1 | 4 | 2 | 7 |
| Teeth guards | | 5 | 2 | 7 |
| Groin protectors (cups) | 1 | 4 | 1 | 6 |
| Competent officials | 2 | 2 | 1 | 5 |
| 14 ounce gloves | | 3 | 1 | 4 |
| Hand wraps | 1 | 2 | 1 | 4 |
| Stop bout when danger appears imminent | 3 | | 1 | 4 |
| Heavier gloves | 1 | 1 | 1 | 3 |
| 16 ounce gloves | | 3 | | 3 |
| Headgear | | 2 | 1 | 3 |
| Follow-up of injuries and knockouts | 1 | | 1 | 2 |
| Revised scoring—reduce or eliminate head blows | 1 | 1 | | 2 |
| 12 ounce gloves | 1 | 1 | | 2 |
| Shortened rounds | | 1 | | 1 |
| No competition | | | 1 | 1 |
| Abdominal supporter | | 1 | | 1 |

ing at institutions that have sponsored some boxing disapproved of intercollegiate boxing for college men both as commonly conducted and with additional control measures and supervision of health factors.

Space was provided on both questionnaires for enlargement of any viewpoints about the place of boxing in higher education. In Table 11 the key statements or basic tenets of comments made by physical education administrators have been categorized. The comments expressed on the health questionnaire were similar. In Table 11 the various opinions are listed along with their frequencies of mention. Since more physical educators who opposed boxing as an educational activity expressed comments than those

who favored its acceptance, these notations do not present an accurate, proportionated picture of general thought. Nevertheless, they do illustrate the many and varied viewpoints about the activity.

Respondents to the questionnaires were requested to enumerate any additional safety measures deemed necessary for boxing in the various programs. Table 12 delineates the measures suggested for intercollegiate competition by persons responsible for health services. Close supervision was mentioned most frequently on the health questionnaire as an additional safety measure for all programs and practice sessions. Adequate instruction, complete or thorough medical examination, and proper conditioning for participants comprised the next most frequently mentioned safety measures for all programs. These same controls were among those suggested the greatest number of times on the questionnaire submitted to physical education administrators.

## SUMMARY

The findings of a questionnaire study to ascertain the status of boxing in institutions of higher learning have been presented. These findings disclosed the extent to which boxing has been sponsored since 1939, facts dealing with its conduct, and opinion about the activity as expressed by physical education administrators and persons directly responsible for health services.

A 78 per cent response was obtained from 794 colleges and universities in the United States. Forty-two per cent of the responding institutions sponsored boxing (instructional, competitive, or both) during the academic year 1948–49.

Boxing was regarded as both desirable and controllable in physical education class, intramural and intercollegiate programs by the majority of responding physical education and health service administrators. A greater percentage favored the activity in the physical education class program than approved of competitive boxing in the other two programs. The plurality of physical educators favored more stringent controls over competitive boxing than those generally followed. The majority of medical doctors serving as health service directors disapproved of intercollegiate boxing.

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# Achievement Tests for Beginning and Intermediate Tennis

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THE WOMENS' PHYSICAL EDUCATION Department at the University of Washington, through its Grading Committees,* has undertaken a long-term project which is designed to standarize and improve grading procedures in various activities. This department is attempting to devise some objective, reliable, and valid means of measuring the achievement of the students in various activities in both the skill and knowledge areas.

It is the purpose of this article to report the progress made in setting up such tests in tennis together with certain statistical data obtained to date.

## Comprehensive Knowledge Test

I. Original Test

A. Content

The various members of the staff teaching tennis conferred and discussed subject matter to be covered in beginning and intermediate tennis courses. Test items, for the most part, were based on the minimum essentials set up as standards for teaching by this committee. As will be pointed out later, this procedure was used to establish the curricular validity of the test.

An experimental test was given to 87 students. This original test consisted of 100 questions which were separated according to content into the following question types:

| | |
|---|---|
| Part I | *True-False* |
| | Position, Timing, Footwork |
| | Fundamental Strokes |
| | Advanced Strokes |
| Part II | *Multiple Choice* |
| | Strategy and Court Position |

* Other members of the Tennis Grading Committee were Helen McLellan, Leone Rulifson, Kathro Kidwell, Katharine Fox, and Emma Spencer.

Part III *Completion*
History, Events, Equipment
Part IV *Matching*
Advanced Strokes
Part V *Yes-No*
Rules and Scoring
Part VI *Identification*
Court Markings
Strategy

The test questions and directions were put in mimeographed form and given to the students who were asked to make notations on any items which they could not understand or which they questioned.

B. Statistical Analysis

1. Reliability

The reliability of the original test was taken on all 87 cases and was computed to be .84 as determined by the split halves method and the Spearman-Brown Formula.

2. Curricular Validity

To satisfy the curricular validity, three techniques were used.

(a) Test items to be included on the original test were determined by an analysis of the knowledge tests already available in this area, textbooks, and the minimum essentials set up as standards for teaching by the tennis committee of the Womens' Physical Education Department of the University of Washington.

(b) Everything covered in the test was included in the curriculum.

(c) The percentage of test items dealing with each phase of the activity agreed as much as possible with the emphasis placed on that particular phase in the course of study.

3. Item Validity

The item validity was found by the upper, lower thirds method. The test papers were divided into upper, middle and lower groups according to total score. Since there was a total of only 87 test papers, the 30 with the highest total scores were used as the upper third and the 30 with the lowest total scores were used as the lower third. The percentage of each group (upper and lower) who failed each item was calculated and the phi coefficient for the item determined.[1] The phi coefficient of each item was found in order to show whether or not the item as worded in the test was useful in discriminating between those who did well on the entire test and those who did poorly. For a group this size a coefficient of .3 was necessary to be acceptable at the 1 per cent level of confidence (to be sure that the item would discriminate in 99 cases out of 100).

[1] C. E. Jurgensen, "Table for Determining Phi Coefficients," *Psychometrika*, 12: 17-29, March, 1947.

II. Revised Test

Those questions with a phi coefficient of .3 and above on the original test were left as originally stated. The items which students had questioned or which showed a phi coefficient under .3 were revised. All these items were re-stated to include the same information in different words and often in a different question form.

A. Content and Question Type

The question types included on the revised test are as follows: Multiple True-False, Multiple Choice, True-False, Short Answer, Matching, and Identification. No attempt was made to place items dealing with certain phases of tennis into a specific question type as was done on the original test. For example: all test items dealing with rules were placed in a "yes-no" type of question on the original test. It was felt that the reliability and validity of certain items would be improved by placing them in another question type.

TABLE 1

*Number and percentage of items devoted to each phase of tennis*

| PHASE | NUMBER | PER CENT |
|---|---|---|
| Equipment | 3 | 2.3 |
| Etiquette | 4 | 3.1 |
| History | 6 | 4.7 |
| Rules and Scoring | 44 | 34.4 |
| Strategy | 19 | 14.8 |
| Techniques | 52 | 40.6 |
| | 128 | 99.9 |

A few questions concerning etiquette, rules and tournament play were added to the revised test, increasing the total number of items from 100 to 128. The Multiple True-False section replaced the Part I True-False section on the original test. Blanks were uniformly arranged on the right hand side of the paper for easy scoring. The number and percentage of items devoted to each phase of tennis in the revised test are presented in Table 1.

B. Statistical Analysis of Revised Test

1. Reliability

The reliability of the revised test was figured on 297 cases of beginning students and 46 intermediate students. It was computed by the same method as the original test which was by correlating the odd and even items (split-halves method) and correcting to actual length by the Spearman-Brown prediction formula. The reliability coefficient for the beginning classes was .82 $\pm$ .013, for the intermediate classes .92 $\pm$ .015, and for the combined beginning and intermediate classes .86 $\pm$ .009.

2. Validity

The item validity was computed only on the 297 tests taken by the beginning classes since there were too few cases for such a study in the intermediate group. The method for determining item validity was the same as that used on the original test. With 297 cases, the 88 (29.6%) papers with the highest total scores were used as the upper group and the 88 (29.6%) papers with the lowest total scores were used as the lower group. This percentage of the papers was selected since this was the point nearest 27% where a natural break in scores occurred. The percent of each of these groups who failed each item was calculated and the phi coefficient for the item determined. For a group this size a coefficient of .226 was necessary to be acceptable at the 1% level of confidence.

While on the original test approximately 30 items showed a high discrimination index (see appendix I), on the revised test approximately 70 items showed a high discrimination index. In addition about 20 other items on the revised test had a phi coefficient of .150 and above which would indicate that, with some revision, these would show acceptable discrimination. In several cases where these items did not discriminate the total difficulty of the item was low. These figures cannot be taken as final since classes taught by five different instructors were involved. In spite of previous agreement on the curriculum, three of the five instructors reported that they had not covered all of the material. This, of course, lowers curricular validity and at the same time definitely affects the discrimination results. For example: 68, 76, 77, 78, 93, 94, 95, 97, 103 were items which were not taught by some of the five instructors involved and, as shown by the table in the Appendix, these items have either a negative or very low phi coefficient. For seven items the phi coefficients were higher on the original test than on the revised test. This would indicate that changes which were made on the original test items were not satisfactory in these cases.

Table 2 shows the range of scores on the entire test for beginning and intermediate students. A comparison of the two distributions can be used as an indication of validity of the total test. It is evident that the intermediate students did better on the test than the beginning students. The beginning group was large enough that the scores should show a fairly normal distribution and Table 2 indicates that these scores do fall into a fairly normal distribution. The mean score for this group was 48.2[2] with a sigma of 12.5. The intermediate group was so small that a completely normal distribution could not be expected. One score is so far below the entire group that the sigma with this score included is 11.5, which is quite large. Without this score the mean for this group is 28.5 and the sigma is 8.8. The scores also indicate that the range was adequate to classify students, on the basis of

[2] Number of items missed.

knowledge, into A, B, C, D, E, groups and therefore the test was useful as a grading device.

## III. Summary and Conclusions

The Comprehensive Knowledge Test has been found to satisfy most of the criteria for a good test.

The test is completely objective. It can be easily administered in 50 minutes. Since all blanks are uniformly arranged for easy scoring, it requires very little time to correct. The physical and technical make-up, language, and general construction satisfy the approved criteria for a good test.

TABLE 2

*Range of scores on comprehensive knowledge test*

| NUMBER ITEMS MISSED | BEGINNING | | INTERMEDIATE |
|---|---|---|---|
| 13–17 | 1 | 4 | 4 |
| 18–22 | 3 | | 8 |
| 23–27 | 17 | 35 | 8 |
| 28–32 | 18 | | 15 |
| 33–37 | 30 | 66 | 4 |
| 38–42 | 36 | | 1 |
| 43–47 | 38 | 87 | 3 |
| 48–52 | 49 | | 2 |
| 53–57 | 43 | 74 | |
| 58–62 | 31 | | |
| 63–67 | 14 | 23 | |
| 68–72 | 9 | | |
| 73–77 | 6 | 8 | 1* |
| 78–82 | 2 | | |
| | 297 | | 46 |

Beginning: Mean—48.2 Sigma—12.5
Intermediate: Mean—29.4 Sigma—11.5
* Without this one low score the mean for the intermediate group is 28.5 and the sigma is 8.8.

The reliability for the beginning group was found to be .82, for the intermediate group .92, and for the combined group .86. The percentage difficulty of individual questions ranged from 3.7 to 93.9 per cent. The range in total scores was from 13 to 82 for the entire group. A comparison of the two distributions indicates the validity of the test. Since the test showed a normal distribution of scores, it was possible to use it as a grading device.

When the test was constructed, it was felt that curricular validity would be satisfied since everything covered in the test was included in the curriculum; however, it was found that certain items were not taught by some of the instructors and that this affected both the curricular validity and the item validity. Curricular validity was satisfied to the extent that the percentage of test items dealing with each phase was agreed upon by the com-

mittee and corresponded, as much as possible, with emphasis placed on that particular phase during the course.

All items have not been shown to be highly valid and considerable more work needs to be done in the revision of some of these. However, 70 items on the revised test as compared with 30 items on the original test showed a high validity. In addition about 20 other items showed a nearly acceptable validity. As already pointed out, the validity of nine items was decreased by the fact that certain instructors did not teach some of the material outlined in the curriculum.

The test itself has been useful as a knowledge grading device since test scores have enabled the various instructors to classify students into A, B, C, D, E groups with ease. Procedures formulated in the construction of this test have served as a guide to grading committees in other activities in the construction of written examinations.

**Forehand-Backhand Drive Test**

I. Purpose

A constant need has been felt for an objective skill test which would help define the performance necessary for grades A, B, C, D, E and which might also serve to classify the students near the beginning of the term into beginning, intermediate, and advanced groups. The one tennis skill test which has been studied extensively is that constructed and reported by Joanna Dyer.[3] Since the Dyer Test gives one score as a measure of tennis ability in general it does not indicate in which primary area a student's weakness lies. While this test is on the whole administratively economical to conduct, its use with large numbers is limited by the availability of a tennis backboard or a fairly extensive free wall space.

The usefulness of available tests to measure skill in the forehand drive and backhand drive has been limited by inadequate statistical study on such tests. The primary purpose of this experimental study, therefore, was to determine, as far as possible, the effectiveness of an extremely simple objective skill test in tennis which could be used as a grading device as well as to point up relative weakness and strength in forehand and backhand drives.

Probably the greatest obstacle in setting up a valid and reliable tennis drive test has been the difficulty of putting the ball into play in such a way that every student would have an equal opportunity for success. A good ball throwing machine which can be set to toss balls within a certain specified small area is the best answer. Every school cannot afford the luxury of such equipment, but the problem of grading is always present.

In an attempt to find some grading device which would be objective, which would do away with the necessity of tossing the ball to the student, and which would be easily as well as quickly administered, the following test was tried.

[3] Joanna Thayer Dyer, "Revision of the Backboard Test of Tennis Ability," *Research Quarterly*, 9(1): 25–31, March, 1938.

## II. Subjects

The subjects for this study were a group of 59 beginning and intermediate tennis players. Group I consisted of 27 students participating in an intermediate tennis class and Group II consisted of 32 students in a beginning tennis class.

## III. Description of Test

The test was designed to measure students' ability to place forehand and backhand drives into the backcourt area. It consisted of hitting a given number of balls so that they would pass between the top of the net and a restraining rope placed above the net, and of attempting to place these balls into the back 9 feet of the court. The ball was put into play by the student bouncing the ball to herself.

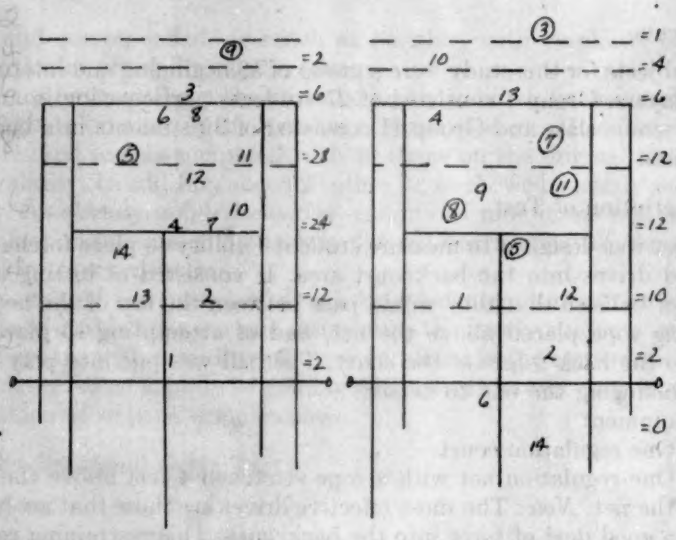
A. Equipment

1. One regulation court.
2. One regulation net with a rope stretched 4 feet above the top of the net. *Note:* The most effective drives are those that are hit with a good deal of force into the backcourt. This restraining rope is a device to measure, to a degree, the force of the drive. A ball passing between the net and this restraining rope and landing in the backcourt area must have been hit with more force than a ball going high (over the rope) and landing in the same area. Driver constructed a tennis test which made use of the restraining rope placed 7 feet above the top of the net.[4] However, during experimentation it was observed that a restraining rope placed that high did not discriminate between players of varying ability; i.e., it was possible for a player to hit balls slowly and with little force 7 feet high and have them hit in the backcourt and therefore score as high as a player who hit fast low drives.
3. One racket and 15–20 balls in good condition.
4. Score sheets for each player (see Figure I) and pencils.
5. Special court markings (see Figure II).
   a. Two chalk lines drawn across the court 10 feet inside the service line and 9 feet outside the service line and parallel to it.
   b. Two chalk lines drawn across the court 5 feet and 10 feet respectively outside the baseline and parallel to it.
   c. Chalked numbers in the center of each area to indicate its scoring value.

B. Test

1. The player taking the test stands behind the baseline, bounces the balls to herself, hits the balls and attempts to place them in in the back 9 feet of the opposite court.
2. Each player is allowed fourteen trials on the forehand and fourteen trials on the backhand.

[4] Helen Irene Driver, *Tennis for Teachers*, Phila., Penn.: W. B. Saunders Co., 1941, p. 163.



| Name | Jane Doe |
|---|---|
| Forehand Score | 74 |
| Backhand Score | 47 |
| Total Score | 121 |

FOREHAND BACKHAND

FIGURE I. Completed score card for forehand-backhand drives

The trial number is marked in the same relative position on the score card as the ball lands on the court. The circle around the number indicates that the ball went over the restraining rope and therefore receives only half the scoring value of the area in which it hits.

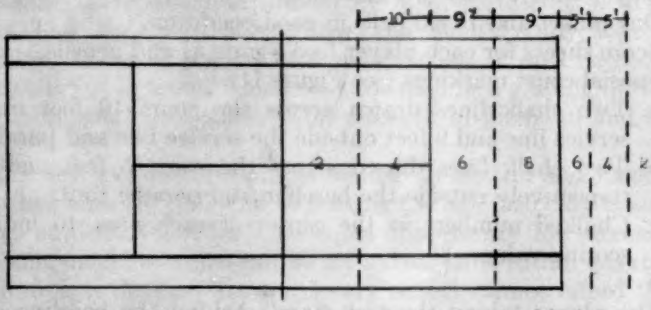


FIGURE II. Special court markings for forehand-backhand drive test

3. In order to score the values as shown on Figure II, balls must go between the top of the net and the rope and land in the designated area or on lines bounding the area (balls landing on a line receive the highest score for that area).

4. Balls which go over the rope score one-half the value of that area in which they land.
5. If the player misses the ball in attempting to strike it, it is considered a trial.
6. Let balls are taken over.

C. Scoring[5]

1. The number of each trial is marked on the score card diagram in the same relative position as the ball landed on the court. (See Figure I).
2. Each ball hit is scored 2-4-6-8-6-4-2, depending upon the area in which it lands. *Note:* Each ball going over the rope is scored one-half the value of the area in which it lands (this may be indicated by circling the ball number on the scoring diagram).
3. The total score equals the sum of fourteen balls on the forehand and fourteen balls on the backhand.

## IV. Statistical Analysis

### A. Reliability

The reliability of the test was computed by correlating the total score of the first 7 balls on the forehand plus the first 7 balls on the backhand with the total score of the second 7 balls on the forehand plus the second 7 balls on the backhand and predicting[6] the validity of a test twice as long. The reliability for the beginning group was shown to be .80 $\pm$ .047, and for the intermediate group was shown to be .80 $\pm$ .043.

### B. Validity

It was decided that, prior to the student's taking the test, the instructor and other judges, who were qualified tennis instructors, would make comparative ratings of the student's ability according to certain standards set up by the Tennis Grading Committee. The purpose of this procedure was to validate the test as a method of grading form on the forehand and backhand drives. These subjective ratings given to the students by the instructor teaching the class and by the other selected judges were used as the criteria. In the intermediate group (Group I) ratings were given by the instructor and one judge. In the beginning group (Group II) ratings were given by the instructor and two other judges.

The validity of the test was computed by correlating the ratings given to the student by the various judges with the students' performance on the test. In Group I (intermediate) the correlation of the two judges' combined subjective rating with the test was .85. The correlation between

[5] Since the test was designed to measure the ability to place the drives in the back court, it was necessary to give some scoring value to those areas which are just outside the desired area. Trials which hit a few feet beyond the back 9 feet of the court should not be penalized any more than those which hit a few feet short—even though those which are short hit within the court.

[6] Spearman-Brown Prophecy Formula.

the instructor's subjective rating of the student and the test was .87 while the correlation between the subjective rating made by Judge 2 and the test was .74. The subjective ratings of these two judges showed a correlation of .83 (See Table 3).

In Group II (beginning) the correlation between the combined subjective rating of the three judges and the test was .61. The correlation between the instructor's subjective rating and the test was .66. The correlations of the subjective ratings made by Judges 2 and 3 with the test were .47 and .46, respectively. The subjective ratings of these three judges varied greatly as shown by intercorrelations of .56, .58, and .35 (see Table 4).

TABLE 3*

*Correlation of subjective ratings and test scores on forehand-backhand drive test*

| JUDGES | JUDGE 2 | TEST SCORE |
|---|---|---|
| Judge 1 (Instructor) | .82 | .87 |
| Judge 2 | | .74 |
| Average of Judges 1-2 | | .85 |

* Group I (Intermediate). Results obtained on 27 college women in the intermediate tennis class.

TABLE 4*

*Correlation of subjective ratings and test scores on forehand-backhand drive test*

| JUDGES | JUDGE 2 | JUDGE 3 | TEST SCORE |
|---|---|---|---|
| Judge 1 (Instructor) | .56 | .58 | .66 |
| Judge 2 | | .35 | .47 |
| Judge 3 | | | .46 |
| Average of 1-2-3 | | | .61 |

* Group II (Beginning). Results obtained on 32 college women in the beginning tennis class.

Lower correlations are to be expected with beginning groups due to the fact that beginners are less consistent. This also partially accounts for the higher validity correlation between the test score and the subjective judgment of the instructor of the class who was well acquainted with their abilities. The judgment of the other tennis instructors was based on one day's observation only.

## V. Summary and Conclusions

The results of this test are based on very small groups and can, therefore, only be taken as indications.

The test as constructed here with fourteen trials of each drive (forehand and backhand) seems to be fairly reliable.

The test seems to be more valid for the intermediate group than for the beginning group since the validity coefficients obtained by correlations

between the judges' subjective ratings of the students and the results of the test were very low for the beginning group and acceptable for the intermediate group. However, the ratings of Judge 1, who was the instructor of the class, agree more nearly with the test scores than with the subjective ratings of either of the other judges for the beginning group. Judges 2 and 3 agreed more with Judge 1 (instructor) than with the test scores but less with each other than with the test scores. The agreement between subjective ratings and the test is, in general, higher than the agreement between the subjective ratings of the various judges grading the classes. Therefore, the test can be said to be an improvement over the judgment of qualified tennis instructors as a means of grading forehand and backhand form. The validity correlations are high enough, particularly between the instructor's subjective judgment and the results of the test, to warrant more intensive investigation.

It was found that approximately 30 students can be tested in one hour with one instructor recording. It would be very possible to teach the students to record for each other and the testing time would then be negligible.

The test shows promise of being a practical and useful objective grading as well as a classifying device.

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# APPENDIX I

*Difficulty and item validity ratings*
Knowledge Examination

| $N_2$ | %D | %1 | %2 | $PC_1$ | $PC_2$ |
|---|---|---|---|---|---|
| 1 | 7.1 | 3.4 | 13.6 | 0 | .197 |
| 2 | 9.8 | 11.4 | *11.4 | .450* | 0 |
| 3 | 5.4 | 3.4 | 9.1 | | .126 |
| 4 | 5.4 | 1.1 | 3.4 | −.033 | .071 |
| 5 | 8.4 | 6.8 | 12.5 | | .085 |
| 6 | 23.2 | 20.5 | 34.1 | | .158 |
| 7 | 21.2 | 11.4 | 30.7 | | .246* |
| 8 | 28.6 | 20.5 | 44.3 | | .257* |
| 9 | 9.1 | 9.1 | 12.5 | .333* | .049 |
| 10 | 14.5 | 3.4 | 12.5 | .264 | .171 |
| 11 | 44.4 | 23.9 | 63.6 | | .403* |
| 12 | 16.2 | 4.5 | 25.0 | .130 | .298* |
| 13 | 26.9 | 18.2 | 38.6 | −.050 | .220* |
| 14 | 8.1 | 5.7 | 11.4 | .229 | .090 |
| 15 | 6.1 | 3.4 | 12.5 | −.184 | .171 |
| 16 | 53.9 | 45.5 | 71.6 | .551* | .700* |
| 17 | 37.7 | 32.9 | 50.0 | 0 | .173 |
| 18 | 74.7 | 62.5 | 77.3 | | .163 |
| 19 | 13.5 | 10.2 | 17.0 | .277 | .102 |
| 20 | 55.9 | 48.9 | 55.7 | | .060 |
| 21 | 3.7 | 2.4 | 10.2 | .154 | .168 |
| 22 | 58.9 | 50.0 | 64.8 | | .152 |
| 23 | 25.3 | 9.1 | 40.9 | −.073 | .370* |
| 24 | 52.9 | 39.8 | 65.9 | | .260* |
| 25 | 50.2 | 40.9 | 61.4 | | .200 |
| 26 | 12.8 | 10.2 | 18.2 | 0 | .115 |
| 27 | 40.7 | 42.0 | 39.8 | .131 | −.020 |
| 28 | 20.9 | 15.9 | 28.4 | .229 | .145 |
| 29 | 17.8 | 17.0 | 26.1 | .039 | .110 |
| 30 | 18.2 | 18.2 | 22.7 | .075 | .062 |
| 31 | 19.2 | 22.7 | 18.2 | −.158 | −.049 |
| 32 | 29.3 | 28.4 | 34.1 | .143 | .065 |
| 33 | 26.3 | 22.7 | 30.7 | | .090 |
| 34 | 55.6* | 35.2 | 80.7 | .309 | .466* |
| 35 | 46.8 | 45.5 | 54.5 | −.153 | .080 |
| 36 | 26.9 | 17.0 | 33.0 | .325 | .185 |
| 37 | 25.9 | 12.5 | 44.3 | | .356* |
| 38 | 13.1 | 3.4 | 28.4 | | .345* |
| 39 | 47.8 | 39.8 | 56.8 | | .170 |
| 40 | 54.2 | 26.1 | 80.7 | | .551* |
| 41 | 82.5 | 71.6 | 93.2 | | .276* |
| 42 | 65.7 | 40.9 | 87.5 | .271 | .499* |
| 43 | 53.5 | 10.2 | 79.5 | | .694* |
| 44 | 52.2 | 18.2 | 84.1 | .286 | .660* |
| 45 | 49.8 | 13.6 | 86.4 | .219 | .720* |
| 46 | 65.0 | 50.0 | 93.2 | .184 | .476* |
| 47 | 8.8 | 4.5 | 10.2 | 0 | .118 |
| 48 | 15.5 | 13.6 | 19.3 | | .067 |
| 49 | 5.1 | 2.4 | 4.5 | | .059 |
| 50 | 17.5 | 6.8 | 12.5 | | .085 |

* Items discriminating at the 1% Level of Confidence.
$N_2$ Number of item on revised test.
%D Per cent of people missing item.
%1 Per cent of upper group missing item.
%2 Per cent of lower group missing item.
$PC_1$ Phi coefficient of each item (discrimination rating) on original test.
$PC_2$ Phi coefficient of each item on revised test.

## APPENDIX I—*Continued*

*Difficulty and item validity ratings—Continued*

| N₂ | %D | %1 | %2 | PC₁ | PC₂ |
|---|---|---|---|---|---|
| 51 | 14.1 | 5.7 | | .140 | .185 |
| 52 | 12.8 | 14.8 | 14.8 | | 0 |
| 53 | 3.7 | 0 | 5.7 | −.056 | .176 |
| 54 | 6.7 | 2.4 | 11.4 | | .183 |
| 55 | 34.3 | 30.7 | 37.5 | .280 | .074 |
| 56 | 26.6 | 17.0 | 35.2 | .143 | .205 |
| 57 | 7.4 | 2.4 | 14.8 | .115 | .233* |
| 58 | 46.5 | 37.5 | 53.4 | .229 | .161 |
| 59 | 5.1 | 3.4 | 4.5 | | .051 |
| 60 | 5.4 | 1.1 | 13.6 | | .247* |
| 61 | 32.0 | 27.3 | 34.1 | | .076 |
| 62 | 13.5 | 4.5 | 28.4 | | .327* |
| 63 | 33.7 | 23.9 | 49.9 | .336* | .260* |
| 64 | 47.5 | 19.3 | 77.3 | .389* | .580* |
| 65 | 47.5 | 26.1 | 70.5 | .362* | .440* |
| 66 | 50.5 | 25.0 | 78.4 | .634* | .540* |
| 67 | 53.2 | 43.2 | 64.8 | .105 | .221* |
| 68 | 93.9 | 95.5 | 94.5 | .241 | −.022 |
| 69 | 42.4 | 10.2 | 76.1 | .312 | .667* |
| 70 | 19.5 | 3.4 | 28.4 | .264 | .345* |
| 71 | 25.6 | 17.0 | 28.4 | | .132 |
| 72 | 41.4 | 20.5 | 64.8 | .173 | .455* |
| 73 | 40.7 | 18.2 | 62.5 | −.092 | .496* |
| 74 | 37.0 | 13.7 | 56.8 | .154 | .449* |
| 75 | 46.1 | 17.0 | 83.0 | .297 | .660* |
| 76 | 37.0 | 29.5 | 42.0 | .430* | .125 |
| 77 | 65.6 | 65.9 | 72.7 | .370* | .076 |
| 78 | 33.3 | 40.9 | 29.5 | .601* | −.125 |
| 79 | 10.4 | 3.4 | 20.5 | .476* | .277* |
| 80 | 21.2 | 12.5 | 25.0 | .488* | .153 |
| 81 | 42.8 | 37.5 | 48.9 | .436* | .121 |
| 82 | 58.2 | 40.9 | 73.9 | .300 | .334* |
| 83 | 20.5 | 10.2 | 34.1 | .283 | .290* |
| 84 | 43.4 | 38.7 | 52.3 | .389* | .131 |
| 85 | 17.8 | 11.3 | 30.7 | 0 | .246* |
| 86 | 16.5 | 7.9 | 23.9 | .140 | .218 |
| 87 | 19.5 | 11.3 | 29.5 | | .235* |
| 88 | 42.1 | 28.4 | 58.0 | .125 | .303* |
| 89 | 6.7 | 2.4 | 14.8 | .229 | .233* |
| 90 | 40.0 | 28.4 | 54.5 | .056 | .264* |
| 91 | 59.2 | 52.3 | 75.0 | .138 | .239* |
| 92 | 18.5 | 13.7 | 28.4 | .190 | .172 |
| 93 | 50.2 | 50.0 | 50.0 | .266 | 0 |
| 94 | 46.5 | 42.0 | 47.7 | | .060 |
| 95 | 33.0 | 29.5 | 35.5 | .207 | .085 |
| 96 | 80.1 | 56.8 | 95.5 | .173 | .453* |
| 97 | 5.1 | 6.8 | 8.0 | .264 | .019 |
| 98 | 76.8 | 59.1 | 95.5 | .488* | .428* |
| 99 | 48.5 | 14.8 | 81.8 | .606* | .670* |
| 100 | 85.6 | 68.2 | 95.5 | .343* | .364* |
| 101 | 26.3 | 20.5 | 30.7 | .266 | .114 |
| 102 | 26.0 | 21.6 | 40.9 | .266 | .205 |
| 103 | 92.9 | 94.3 | 95.5 | .241 | .046 |
| 104 | 26.9 | 13.7 | 44.3 | .280 | .331* |
| 105 | 59.9 | 48.9 | 70.5 | .305 | .225* |
| 106 | 30.0 | 10.2 | 56.8 | | .498* |
| 107 | 78.1 | 51.1 | 98.9 | | .554* |
| 108 | 78.5 | 55.7 | 96.6 | | .483* |

## APPENDIX I—*Continued*

*Difficulty and item validity ratings—Concluded*

| $N_3$ | %D | %1 | %2 | $PC_1$ | $PC_2$ |
|---|---|---|---|---|---|
| 109 | 64.0 | 42.0 | 92.0 | .474* | .532* |
| 110 | 30.0 | 8.0 | 54.5 | .532* | .506* |
| 111 | 50.2 | 30.7 | 69.3 | .515* | .380* |
| 112 | 54.6 | 28.4 | 84.1 | .471* | .564* |
| 113 | 42.8 | 30.7 | 68.2 | .531* | .370* |
| 114 | 78.1 | 56.8 | 97.7 | .219 | .491* |
| 115 | 60.6 | 34.1 | 83.0 | .297 | .497* |
| 116 | 63.0 | 40.9 | 87.5 | .390* | .467* |
| 117 | 79.8 | 63.6 | 88.6 | .173 | .267* |
| 118 | 26.3 | 4.5 | 47.7 | .589* | .487* |
| 119 | 51.9 | 39.8 | 74.0 | .074 | .354* |
| 120 | 31.0 | 9.1 | 52.3 | .047 | .467* |
| 121 | 33.7 | 17.0 | 61.4 | .425* | .451* |
| 122 | 12.1 | 1.1 | 26.1 | −.074 | .366* |
| 123 | 21.9 | 18.2 | 38.7 | .362* | .233* |
| 124 | 6.4 | 2.4 | 14.8 | .395* | .233* |
| 125 | 41.8 | 20.5 | 54.5 | −.074 | .350* |
| 126 | 76.1 | 48.9 | 94.3 | .503* | .498* |
| 127 | 60.3 | 26.1 | 88.6 | .461* | .637* |
| 128 | 64.3 | 35.2 | 79.8 | .578* | .568* |

## APPENDIX II

*Comprehensive Tennis Examination*

University of Washington

Name.....

Instructor.....

Answer all questions as for right-handed players.

*Score Summary*

1. Multiple True-False .....
2. Multiple Choice .....
3. True-False .....
4. Identification .....
5. Completion .....
6. Matching .....
7. Identification .....

Total .....

**Part I. Multiple True-False:** If the statement is entirely correct, encircle the "T." If the statement is totally or partially incorrect, encircle the "F."

A. Loss of force in a forehand drive stroke results from
1. transferring the weight from the rear foot to the foreward foot..... T F
2. using a long backswing..... T F
3. holding the elbow close to the body..... T F

B. When using the Eastern forehand grip
4. the player shakes hands with the racquet..... T F
5. the same racquet face contacts the ball on the forehand and backhand drives..... T F
6. the thumb curves around the handle of the racquet..... T F
7. the forefinger is extended directly up the handle of the racquet..... T F
8. the racquet face should be perpendicular to the ground when the player grasps the racquet..... T F

C. At the moment of impact with the ball
9. the racquet should be held loosely..... T F
10. the racquet head should be lower than the wrist..... T F
11. the racquet face should be closed..... T F

D. In order to insure proper timing a player should
12. wait until the ball bounces before moving into position for the stroke. T F
13. take the backswing while moving into position..... T F
14. keep weight on her heels..... T F
15. attempt to get in the direct path of the ball..... T F

E. Putting top spin on the ball
16. increases the speed of the ball..... T F
17. makes the ball stay in the air longer..... T F
18. makes the ball bounce low..... T F

F. In serving, the ball should be
19. tossed as the racquet begins to swing down and back..... T F
20. released when the hand is approximately at shoulder level..... T F
21. hit with the racquet arm fully extended..... T F
22. hit above the right shoulder..... T F

G. When executing a volley stroke
23. a shortened swing should be used..... T F
24. the elbow is extended throughout the stroke..... T F
25. the ball should be met well in front of the body..... T F

H. In executing the forehand drive
26. the follow-through should be in the direction of the intended ball flight..... T F
27. one should attempt to hit the ball when it is in line with the left foot.. T F
28. one should face the right alley..... T F
29. one should attempt to play the ball when it is waist high..... T F

I. In executing the backhand drive
30. the palm of the racquet hand should be facing the ground with the thumb extended along the left side of the handle..... T F
31. the right shoulder should point toward the left alley at full backswing T F
32. the racquet should lead the arm on the forward swing..... T F
33. the left foot should be nearer the alley than the right foot..... T F

J. In executing a drive, a beginner should
34. stroke the ball on the rise or as soon after the bounce as possible.... T F
35. look at the spot where she wants to place the ball..... T F
36. strive to get height in the ball flight in order to send drives to the back court..... T F

K. Lobs should
37. be made only at the net..... T F
38. be used to force the opponent from a position near the net..... T F
39. have a backswing which looks like a drive backswing except that it is slightly shorter..... T F

L. In the American twist service
40. the racquet contacts the ball behind the head..... T F
41. the follow-through is near the left ankle..... T F
42. the bounce of the served ball is high..... T F
43. the ball is given top and side spin..... T F

M. In the early history of tennis
44. the tennis court resembled an hourglass..... T F
45. the ball was played with the hand..... T F
46. the balls were made of canvas..... T F

N. A footfault occurs when the server, while in the act of serving
47. changes position by walking..... T F
48. steps on the baseline after her racquet strikes the ball..... T F
49. jumps with both feet off the ground before the racquet strikes the ball..... T F
50. takes one foot off the ground before the racquet strikes the ball..... T F

O. It is good strategy to
51. develop a change of pace in strokes ..... T F
52. go to the net when the opponent is at the net ..... T F
53. play to the opponent's weakness ..... T F
54. avoid using the backhand stroke ..... T F

P. A player loses the point if
55. she is standing behind the baseline and catches a ball before it bounces ..... T F
56. she reaches over the net to strike an oncoming ball but doesn't touch the net ..... T F
57. she hits the ball on her side of the net and allows her racquet to swing across the net on the follow-through without touching the net ..... T F
58. as she makes a good return, the racquet slips from her hands and falls into the opponent's court ..... T F

Q. It is considered good tennis etiquette
59. in the absence of an umpire, for the server to call the score before serving ..... T F
60. to recover balls from another court, where play is in progress, by running on that court and getting the ball out of the way quickly ..... T F
61. for a spectator to applaud good strokes as they occur during the rally . T F
62. to question the umpire if one disapproves of her decision ..... T F

Part II. Multiple Choice: Place a figure X opposite the statement which best applies to the particular situation.

63. When serving in singles the server should stand behind the baseline
a. halfway between the center mark and the singles side line ..... ( )
b. near the singles side line ..... ( )
c. near the center mark ..... ( )
d. behind the alley ..... ( )

64. While rallying, doubles players should assume a court position in which
a. partners are diagonally opposite each other ..... ( )
b. partners are directly behind each other ..... ( )
c. partners are parallel to each other ..... ( )
d. one player covers half the net and her partner covers the entire backcourt ..... ( )

65. In singles, after each stroke made near the baseline, the player should assume a position
a. between the service line and baseline ..... ( )
b. behind the center of the baseline ..... ( )
c. near the net ..... ( )
d. behind the baseline where the last stroke was made ..... ( )

66. When playing defensively a player should stand
a. between the service line and the baseline ..... ( )
b. near the net ..... ( )
c. behind the baseline ..... ( )
d. on the service line ..... ( )

67. If a player swings at a ball before it bounces but misses it and the ball lands outside the court
a. she wins the point ..... ( )
b. she is considered as having played the ball ..... ( )
c. her opponent wins the point ..... ( )
d. the point is played again ..... ( )

68. In a women's match a rest period may be taken
a. after the first set ..... ( )
b. any time ..... ( )

c. after second set ( )
d. at a time agreed upon by both players ( )

69. Net position is considered the position for
a. drive strokes ( )
b. defense play ( )
c. lob strokes ( )
d. offense play ( )

70. A set is completed
a. when the server has 6 games and the receiver has 5 games ( )
b. when the server has 4 games and the receiver has 2 games ( )
c. when the server has 7 games and the receiver has 6 games ( )
d. when the server has 6 games and the receiver has 4 games ( )

Part III. True-False: If the statement is entirely correct, encircle the "T." If the statement is totally or partially incorrect, encircle the "F."

71. In singles a player should advance to the net when her opponent is using a backhand stroke T F
72. Advanced doubles is primarily a baseline game T F
73. Ash is considered the best quality of wood for tennis racquets T F
74. Lambs' gut is considered the best quality of gut for stringing racquets T F
75. The first game resembling our modern game of tennis came from Ireland. T F
76. If a player wins the toss, she must serve first T F
77. A player may serve underhand T F
78. The ball may be played by holding the racquet in both hands T F
79. When both sides have won three points the score is "thirty all" T F
80. It is necessary for the receiver of the service to stand in the court T F
81. The score is "games-all" when both sides have won 4 games T F
82. For a block volley, a player should stand about two feet behind the service court line T F
83. If a let is called in the middle of a rally, the server is entitled to serve two more balls even though the first ball served was a fault T F
84. The overhead smash is best executed from the backcourt T F
85. After serving a fault the second ball should be served with very little force T F

Part IV. Which of the following situations would give a point to the server, a fault to the server, or a let to the server? Encircle "P" for point, "F" for fault, and "L" for let.

86. While serving, the server misses the ball in attempting to strike it P F L
87. A served ball touches the receiver before it touches the ground P F L
88. The server wins the rally, then discovers her partner should be serving P F L
89. A served ball hits on the line between the receiver's right and left service courts and is not returned P F L
90. The server wins the rally then discovers she served from the wrong court P F L
91. While standing behind the ally, the server in a singles game served into the proper service court and the receiver fails to return the ball P F L
92. The server hits the first ball into the net and the second ball goes out-of-bounds P F L
93. The receiver returns a served ball for which she claims she was not ready and the returned ball goes out of the court P F L
94. The served ball hits the receiver's partner before it touches the ground P F L
95. The served ball strikes another ball which has rolled into the receiver's service court P F L

Part V. Completion: Answer the following questions in one or two words.
96. Which is the most effective stroke in doubles play? .....
97. Which player's score is called first? .....

98. What is the name of the cup presented to the winner of the competition between women in the U. S. and England?.....
99. What is the name of the cup presented to the winner of the international competition event for men only?.....
100. What type of surface on a court plays the ball faster than any other type?.....
101. What is the maximum number of sets in a match for women?.....
102. What is the score when the server has won one point after deuce?.....
103. What is the maximum number of minutes allowed for the rest period in a women's match?.....
104. If, during the service, a served ball touches the top of the net and goes into the proper court, what is this ball called?.....
105. When should players change sides of the net?.....
106. In the absence of an umpire who should determine whether or not the service is good?.....
107. What has a player, who does not have to play the first round of a tournament but who is immediately advanced to the 2nd round, received?.....
108. What is the loser in the final round of a tournament called?.....

Part VI. Matching: The descriptions in Column II apply to some of the words or phrases in Column I. Place the appropriate letter from Column I in the blanks provided in Column II.

*Column I*

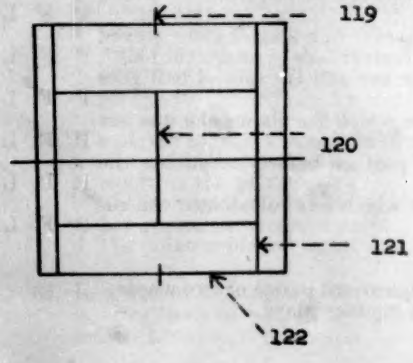
A. angled shot
B. American twist
C. cannon ball
D. chop
E. drop shot
F. half volley
G. lob
H. side spin
I. slice
J. smash
K. stop or block volley
L. top spin
M. volley

*Column II*

109. A stroke which produces back spin on the ball.....
110. A stroke made by hitting the ball before it touches the ground.....
111. An effect which is produced by drawing the racquet strings over the top of the ball as it is struck.....
112. A stroke made by hitting the ball just after it bounces off the ground.....
113. A stroke used to return a lob and which resembles the service stroke.....
114. A stroke which causes the ball to bounce low to the left.....
115. A stroke in which the racquet meets the ball and does not follow through.....
116. A flat hard service.....
117. A stroke which gives excessive spin to the ball and causes it to bounce in a high arc.....
118. A stroke which lofts the ball above and beyond the reach of opponent at the net.....

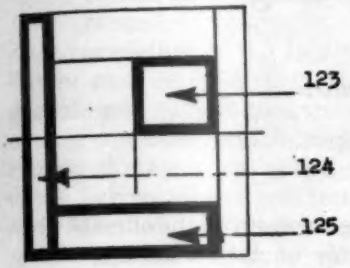
Part VII. Identification

A. Give the official names of the *lines* of the court that are numbered in the diagram by placing the name in the blank provided.




119. .....
120. .....
121. .....
122. .....

B. Give the official names of the *spaces* of the court that are numbered in the diagram by placing the name in the blank provided.

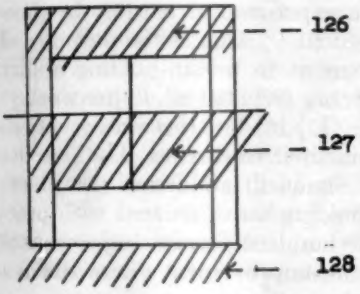



123. .....

124. .....

125. .....

C. Name in terms of strategy the shaded *zones* that are numbered in the diagram by placing the name in the blank provided.




126. .....

127. .....

128. .....

# An Analysis of Breath-Holding Tests

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NUMEROUS investigators have observed the effect of physical conditioning, diet, or some other factor on breath-holding ability. Despite the lack of adequate controls in many of these studies (2, 5, 7, 12, 13, 15, 19), the change (or lack of change) in breath-holding time was attributed to the effect (or lack of effect) of the experimental factor. In certain other breath-holding studies of an experimental nature the presence or absence of controls was not specified (6, 9). One of the purposes of this study was to determine the improvement in breath-holding ability which may be expected merely through practice (repetition). Other workers have noticed that improvement does occur (11, 16) but these observations were incidental to the principal problems in their researches. The practice effects themselves were not investigated. Simonelli and Ferri (18), however, plotted the improvement in breath-holding that occurred with practice. In their few subjects they secured one hundred percent improvement after only a few weeks. In one subject, the improvement curve did not show signs of leveling off even after 23 trials.

A second purpose in carrying out this project was to determine to what degree breath-holding times are affected by the duration of moderate exercise taken immediately before the breath-holding tests. The effect of intensity of exercise preceding breath-holding has been reported by Rodbard (14). He observed that the length of time the breath was held was indirectly proportional to the number of footpounds of work performed in fifteen seconds on a bicycle ergometer. The effect of the duration of exercise apparently has not been studied.

## Procedure

The group of subjects comprised twenty-two college men all of whom were physical education majors. None, however, was a member of a varsity team. All were secured on a volunteer basis. The sample is probably representative within these limits.

The battery of breath-holding tests included the following:

1. Normal breath-holding (i.e., not preceded by exercise).
2. Breath-holding after one minute of stepping up on to a seventeen inch bench at the rate of thirty steps per minute.

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3. Breath-holding after two minutes of stepping (same bench and tempo).
4. Breath-holding after five minutes of stepping (same bench and tempo).

After completion of the four tests the battery was repeated twice more. Within each series of four tests the order of selection was random. In general, each subject took only one test per day. However, in some cases when the normal breath-holding test was taken, a second test was administered after a rest period of twenty minutes. The time of the day at which a given subject was tested did not vary more than thirty-five minutes. Most of the subjects completed the twelve breath-holding tests within a period of two weeks, although in some cases the testing was distributed over a three week period. If the subject appeared to be definitely affected by a cold or other ailment, the testing was postponed until a later date.[1]

The details of administering the breath-holding tests were as follows:

1. Before beginning each test, the subject was allowed to practice holding his breath a few times for very brief periods in order to become adjusted to the apparatus.
2. A nose clip was used during all tests.
3. Three deep breaths were allowed before beginning the hold, i.e., the breath was held at the end of the third inhalation. Karpovich (8) secured a higher coefficient of reliability using this method as compared to taking only one breath.
4. For the purpose of standardizing intrathoracic pressure the breath was held on the flarimeter (20) with both orifices closed and the water level maintained at the equivalent of 20 mm. Hg pressure. Despite continuous urging on the part of the testor, the water level fluctuated considerably during the last stages of the hold.
5. The tempo during the stepping exercise was maintained by an electric metronome.
6. The time of the hold, to the closest tenth of a second, was measured with the aid of a stop watch.
7. All of the tests were administered by the writer and every effort was made to motivate each subject to go "all-out" on every trial.
8. The subjects were instructed not to practice breath-holding except at the time tests were given.

## Results

A summary of the breath-holding data is presented in Table 1. All of the distributions of scores were unimodal and slightly positively skewed. Graph I shows the improvement in breath-holding ability that occurs

[1] Inasmuch as there was positive pressure in the breathing circuit special care was taken not to administer the test to a subject with a head cold to avoid the possibility of spreading the infection to the ears via the eustachian tubes. Also, Henry (4) reported that colds decrease breath-holding time.

with practice. The effect on breath-holding time of variations in the duration of exercise immediately preceding the test is illustrated in Graph II.

In an effort to determine whether or not the improvement in breath-holding was significant and also whether the duration of exercise preceding the test significantly affected the breath-holding times, the analysis of variance technique was applied to test the means for homogeneity. However, this method, as also the small sample "t" test, involves the assumption of equality of variance among the distributions if the differences between groups are to be attributed to differences in means. In order to

TABLE 1

*Mean, standard deviation, and range of each distribution of breath-holding scores*

| TYPE OF BREATH-HOLDING TEST | MEAN | $\sigma$ | RANGE | N |
|---|---|---|---|---|
| | secs. | secs. | secs. | |
| Normal breath-holding (no exercise) | | | | |
| First trial | 82.7 | 36.1 | 37–182 | 22 |
| Second trial | 100.5 | 36.0 | 60–188 | 22 |
| Third trial | 116.6 | 36.5 | 53–200 | 22 |
| Best score | 119.1 | 34.1 | 72–200 | 22 |
| Breath-holding after 1 min. stepping | | | | |
| First trial | 25.2 | 11.4 | 9–51 | 22 |
| Second trial | 36.9 | 19.4 | 15–110 | 22 |
| Third trial | 43.5 | 22.2 | 12–112 | 22 |
| Best score | 46.1 | 20.7 | 15–112 | 22 |
| Breath-holding after 2 min. stepping | | | | |
| First trial | 24.7 | 14.7 | 11–63 | 22 |
| Second trial | 31.3 | 18.0 | 13–74 | 22 |
| Third trial | 37.8 | 15.0 | 11–69 | 22 |
| Best score | 40.6 | 15.8 | 14–74 | 22 |
| Breath-holding after 5 min. stepping | | | | |
| First trial | 27.0 | 17.1 | 10–80 | 22 |
| Second trial | 32.2 | 16.7 | 11–75 | 22 |
| Third trial | 37.4 | 17.7 | 13–95 | 22 |
| Best score | 39.7 | 16.9 | 13–95 | 22 |

ascertain whether or not this assumption was a reasonable one, the F-ratio test was applied to the sixty-six variance combinations. This test indicated that the differences in variability *among* the distributions of normal breath-holding scores and also *among* the distributions of exercise breath-holding times were insignificant.[2] The differences in variance *between* the normal and exercise breath-holding scores, however, were signifi-

[2] This does not prove that a true difference in variance does not exist but indicates, at least, that the error due to this assumption would probably not appreciably affect the results.

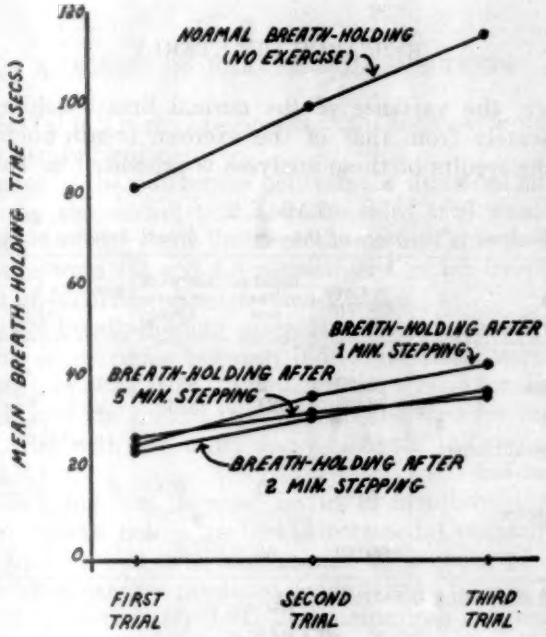


CHART 1

Effect of practice on breath-holding time
(N = 22)

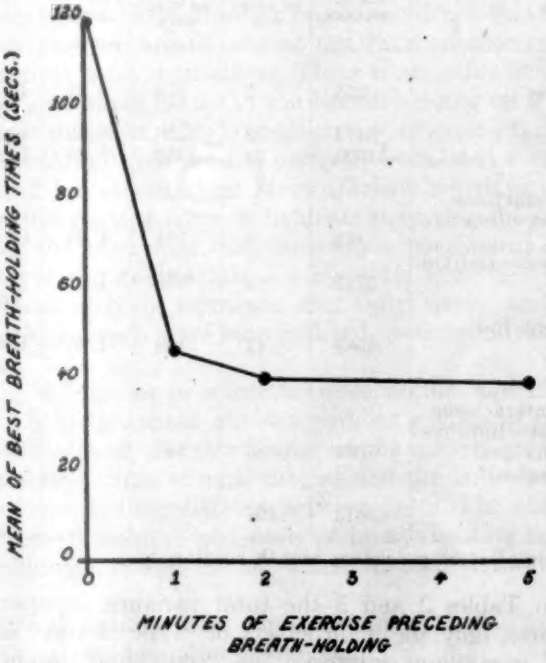


CHART 2

Effect of the duration of preceding exercise on breath-holding time
(N = 22)

cant. Therefore, the variance of the normal breath-holding scores was analyzed separately from that of the exercise breath-holding scores. A summary of the results of these analyses is presented in Tables 2 and 3.

TABLE 2

*Analysis of variance of the normal* breath-holding scores*

| ITEM | SUM OF SQUARES | DEGREES OF FREEDOM | ESTIMATE OF VARIANCE | VARIANCE RATIO | PROBABILITY |
|---|---|---|---|---|---|
| Main Effects | | | | | |
| Improvement | 12623 | 2 | 6312 | 32.5 | Less than 0.001 |
| Individual | 78428 | 21 | 3735 | 19.2 | Less than 0.001 |
| First Order Interactions | | | | | |
| Improvement-Individual | 8131 | 42 | 194 | | |
| (Error Variance) | | | | | |
| Total | 99182 | 65 | | | |

* No exercise preceding breath-holding.

TABLE 3

*Analysis of variance of exercise* breath-holding scores*

| ITEM | SUM OF SQUARES | DEGREES OF FREEDOM | ESTIMATE OF VARIANCE | VARIANCE RATIO | PROBABILITY |
|---|---|---|---|---|---|
| Main Effects | | | | | |
| Type of Test | 555 | 2 | 278 | 3.31 | Between 0.05 and 0.01 |
| Improvement | 6473 | 2 | 3236 | 38.52 | Less than 0.001 |
| Individual | 41009 | 21 | 1953 | 23.25 | Less than 0.001 |
| First Order Interactions | | | | | |
| Type of Test—Improvement | 415 | 4 | 104 | 1.24 | Greater than 0.20 |
| Type of Test—Individual | 5712 | 42 | 136 | 1.62 | Between 0.05 and 0.01 |
| Improvement-Individual | 4588 | 42 | 109 | 1.30 | Between 0.10 and 0.20 |
| Second Order Interactions | | | | | |
| Type of Test—Improvement-Individual | 7061 | 84 | 84 | | |
| (Error Variance) | | | | | |
| Total | 65813 | 197 | | | |

* Exercise immediately preceding breath-holding.

Although in Tables 2 and 3 the total variance is separated into its component parts, only the main effects of "type of test" and "improvement" are of paramount interest. The "individual" main effects refer

to reliability. In Table 2 it may be seen that the increase in normal breath-holding time is highly significant.

The significance of the differences between the first trial and the second trial and between the second trial and the third trial were investigated using the estimate of the error variance shown in Table 2. The resulting significance ratios were 4.2 and 3.8 respectively, which have probabilities less than 0.001 of occurring through chance alone.

Similarly, with breath-holding after exercise, improvement is highly significant. The comparisons between individual trials were made as in the normal breath-holding scores. The significance ratio for the comparison of the first trial with the second trial was 4.0 and that for the comparison of the second trial with the third was 4.1. Again the probabilities were less than 0.001.

A statistically significant decrease occurs in breath-holding time when the duration of exercise before the test is increased. Comparing the results of the breath-holding test after one minute of exercise with the results after two minutes of exercise produced a significance ratio of 2.5 which has a probability of approximately 0.01. The comparison between the breath-holding after two minutes of stepping with the breath-holding after five minutes of stepping resulted in a significance ratio of 0.59, which has a probability between 0.27 and 0.31.

The first order interactions afford no reliable evidence that improvement is greater in one exercise breath-holding test than another or that certain individuals improve more than others. There is an indication that certain subjects perform *relatively* better in the breath-holding tests preceded by exercise of longer duration. This is another way of saying that the various exercise breath-holding tests are not perfectly correlated even when completely corrected for attenuation. More efficient circulatory adjustment to exercise on the part of some individuals may thus be indicated. On the other hand, the advantage may be solely a mechanical one since the standardization of the exercise did not allow for such factors as weight, height, proportion of body segments, etc. Only tempo and duration of work and height of bench were standardized, not the physiological work done.

Although the differences in scores between normal breath-holding and exercise breath-holding appear obvious without statistical treatment, for the sake of completeness the significance of the differences in means was tested using the best times of each subject and the large sample method, taking into account the correlations between tests. The comparisons between normal breath-holding and exercise breath-holding resulted in the following significance ratios, all of which have probabilities less than 0.001:

1. With breath-holding after 1 min. stepping, 13.25
2. With breath-holding after 2 min. stepping, 13.57
3. With breath-holding after 5 min. stepping, 15.93

## Discussion

Improvement in breath-holding of roughly fifty percent in raw scores was secured with a moderate amount of practice. When changes in breath-holding are being investigated, the need for adequate controls or practice until a plateau is reached is thus clearly indicated. Also, the ratio of the standard deviation to the mean in the distributions of breath-holding times (coefficient of variation) was quite high. This explains the difficulty encountered in demonstrating significant differences in studies of breath-holding ability.

The effect of decreasing breath-holding times by increasing the duration of moderate exercise preceding the breath-holding tests was not nearly as pronounced as the effect secured by Rodbard (14) by increasing the intensity of exercise (footpounds of work performed in fifteen seconds). Very likely during the first minute of stepping, an appreciable oxygen debt is formed and the breath-holding times are greatly reduced from normal. As the moderate exercise continues the circulatory system adjusts to the task and the oxygen debt is then accumulated at a much slower rate or not at all. However, when the *intensity* of the exercise is increased, an oxygen debt may continue to accumulate very rapidly even though circulatory adjustments are made.

One other observation should be described. Four of the twenty-two subjects reported that after the breath was held a certain period of time, "it became easy." These four cases had breath-holding scores far superior to those of the other subjects, which fact may account for the skewness in the distribution of scores. There were also objective signs of the lack of distress after the breath was held beyond the "hump," so to speak. One such indication was the water level in the flarimeter which became very steady although just previously it had fluctuated greatly. Furthermore, practically all respiratory movements and tremors were observed to stop completely. In several instances the symptoms seemed to occur abruptly but in general the change required from ten to fifteen seconds. The phenomenon was definitely observed in these four cases and definitely not observed in the others.

Two of these four subjects, during the last stage of the hold, could no longer hear the seconds being called out. This corroborates the observations of Gellhorn and Spiesman (3). These workers demonstrated a marked reduction in hearing ability during anoxia and hypercapnia.

The data are not adequate to determine whether oxygen depletion, carbon dioxide accumulation or both are responsible for the apparent depressed state of the respiratory center in the four subjects. In a few instances an anoxia photometer[2] was attached to the subject's ear. This was the case during one of the unusually long periods of breath-holding (188 secs.) when the symptoms of distress seemed to disappear. At the termination of breath-holding in this trial the oximeter indicated an arterial

[2] Modified ear oximeter manufactured by Coleman Company, Maywood, Illinois.

oxygen saturation of fifty-seven percent. If it can be assumed that the oximeter gives a reasonable approximation of the actual oxygen saturation, anoxia may conceivably be responsible for the phenomenon. However, relatively high concentrations of carbon dioxide are also known to depress the respiratory center (1, 5, 10). Unfortunately the carbon dioxide in the arterial blood or in the alveoli during breath-holding was not determined in these cases.

Schneider (15, 17) expressed the opinion that it is "practically impossible" for a subject to hold his breath until he becomes unconscious. Possibly the inherent or trained capacity to drive one's self to carry on under such conditions is present to a greater extent in physical education majors or individuals with a history of participation in sports. Of course, increasing the intrathoracic pressure as was done in this study would tend to bring on unconsciousness sooner.

## Summary and Conclusions

An analysis-of-variance experimental design was used to study the practice effects of breath-holding before exercise, and after one, two, and five minutes of stepping, and also the effect of the duration of moderate exercise on breath-holding times. Twenty-two men students majoring in physical education were used as subjects. Each subject repeated all four breath-holding tests three times. Breath-holding was done on the flarimeter against the equivalent of 20 mm. Hg pressure with both orifices closed.

On the basis of the results presented the following conclusions appear justified.

1. Roughly fifty percent improvement may be expected in breath-holding time with a moderate amount of practice (three trials). This is true when the breath-holding tests are preceded by moderate exercise as well as when no exercise is taken.
2. Moderate exercise taken before breath-holding decreases the time the breath is held but the *duration* of the exercise is not related to the breath-holding time in a simple proportion as appears to be true for the *intensity* of exercise (14). Increasing the duration of moderate exercise has progressively less effect on breath-holding ability.
3. The four breath-holding tests employed do not measure precisely the same qualities.
4. It is possible for some individuals to hold their breath against 20 mm. Hg pressure until they become unconscious. In these subjects a point is reached during breath-holding when the respiratory center is no longer strongly stimulated.

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20. WELLS, P. V., "The Flarimeter: A Clinical Instrument for Testing Circulatory Fitness," *Review of Scientific Instruments*, **1:** 332–40, June, 1930.

# Learning To Juggle: I. A Study To Determine the Effect of Two Different Distributions of Practice on Learning Efficiency

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PRACTICE is one of the key conditions which must be considered in learning motor skills. This condition may be viewed in the light of at least seven variables whose influence seems to determine the amount of benefit derived from practice: 1) duration of the practice session; 2) length of the rest period between practice sessions; 3) practice method; 4) speed of movement during practice; 5) characteristics of the learner; 6) activity of the learner during the time between practice periods; and 7) complexity of the skill. These and other variables are the subject of much research by those interested in performance improvement.

Since practice does play such a prominent role in the learning of motor skills, it is essential that those charged with teaching these skills have a thorough understanding of the role played by the above mentioned variables during practice. The present study is concerned chiefly with the first two of these, specifically, duration of and the rest between practice periods. How long should a practice session be? How much time should elapse before the session may be repeated for the greatest efficiency? The earlier research on these questions was planned so as to identify the separate effect of each of the two variables. Thus, an experiment would be designed to measure the effect of different lengths of practice periods by maintaining a constant amount of rest between practice sessions and changing the length of the practice. By reversing the above arrangement the effect of different amounts of interpractice rest was studied.

As research on these two variables has continued it has become increasingly clear that there is a relationship between them. Travis, who used a manual pursuit oscillator to study motor learning, states that "the length of the practice periods and the length of the interpractice rest are fundamentally related."[1] He infers that a longer practice period must be followed by a longer rest period for efficient learning. More recently Nance has found distributed paced practice superior to massed

[1] Roland C. Travis. "Length of the Practice Period and Efficiency in Motor Learning," *Journal of Experimental Psychology*, XXIV (March 1939) 339–45.

unpaced, distributed unpaced, and massed paced practice. He adds that "it is probable that the superiority of distributed practice is based upon the magnitude of the work-rest ratio and not upon absolute length of trial or rest taken separately."[2] Further evidence of the interrelationship between practice and rest may be found in the study by Spence, Buxton, and Melton.[3] As reported by Nance,[4] these investigators used four different distributions of practice to measure learning on the S. A. M. Complex Coordination Test. At the end of the work period all the groups using distributed practice were superior to the continuous group. However, the group using the shortest work-rest ratio was *not* the most superior. Dore and Hilgard also emphasize the relationship when they state, "the optimum distribution of practice obviously lies somewhere between that overcrowding which disrupts practice and that separation which allows a loss of previous gains before practice is resumed."[5]

The present writers were interested in testing the inference made by Travis that longer work periods should be followed by longer rest periods for efficient learning. Would such an arrangement be as efficient as a shorter work-rest distribution? Incidentally, many persons inadvertently adopt the longer work-rest distribution when learning motor skills; they are unwilling or unable to practice regularly and attempt to compensate by engaging in long practice sessions with several days to a week intervening. We wanted to find an experimental situation which would employ a type of coordination closely associated with many sports activities and which would permit easy demonstrations to students. The motor skill of juggling was finally selected as a learning situation which would meet these requirements. Juggling or ball-tossing was a favorite subject of study among early psychological researchers, Swift[6] and Pederson[7] being two who reported using this technique. They were primarily concerned with discovering the nature of the learning curve.

## Procedure

*Selection of Subjects.* The subjects in the experiment were University of Illinois male seniors majoring or minoring in physical education. All of these men were doing student teaching in physical education.

Prior to the establishment of the experimental groups the number of

[2] R. Dale Nance. "The Effects of Pacing and Distribution on Intercorrelations of Motor Abilities." Unpublished Ph.D. Dissertation, State University of Iowa, June 1946.

[3] K. W. Spence, C. E. Buxton, and A. W. Melton. "The Effect of Massing and Distribution of Practice on the S.A.M. Complex Coordination Test." Civil Aeronautics Authority, Division of Research, December 1945, No. 53.

[4] R. Dale Nance. *Op. cit.*

[5] Leon R. Dore and Ernest R. Hilgard. "Spaced Practice and the Maturation Hypothesis," *Journal of Psychology*, IV (October 1937), p. 245–59.

[6] Edgar James Swift. *Mind in the Making.* New York: Charles Scribners Sons, 1909. viii + 329.

[7] Joseph Pederson, "Experiments in Ball-tossing: The Significance of Learning Curves," *Journal of Experimental Psychology*, II (June 1947), 178–224.

potential subjects was cut down by eliminating those who already possessed some juggling skill. In a pre-test, consisting of three trials, each subject tried to juggle three paddle tennis balls. Subjects who made five or more consecutive catches on any one of the three trials were eliminated from the experiment.

By means of random selection, the subjects were placed in *two* groups of 35 men each. After the composition of the groups had been established, the backgrounds were studied to determine whether the groups were equal in athletic experience and competence. In terms of such criteria as high school letters, college squads, and college varsity letters the groups were well matched.

*Practice Preparations and Instructions.* An effort was made to orient the subjects in the juggling situation. For example, several demonstrations of juggling were presented. Also, a number of rules and suggestions were given to each subject. These were mimeographed and time was spent in class discussion of the items until each subject felt he fully understood how to proceed. The following is a duplicate of the above mentioned mimeographed material:

A. Rules
   1. Only the whole method is permissible.
      a. You may not practice the hand movements without using balls.
      b. You may not practice the toss and catch using less than three balls.
   2. During a juggle at least one ball must be in the air at all times. If two balls touch a hand simultaneously the count must stop.
   3. Time and distribution of practice sessions, as stipulated for your group, must be followed exactly.

B. Suggestions
   1. Start with two balls in the dominant hand.
   2. Toss and catch the balls with rhythmical movements.
   3. In tossing let the ball leave the hand approximately in front of the chin with the head facing forward.
   4. Toss the ball to a height approximately equal to the top of your head.
   5. Toss the ball so that it may be caught about six inches to the left, or right, of the sternum line at a height slightly above the belt.
   6. Toss the ball to the inside of the ball about to be caught.
   7. Watch the balls with a minimum of eye movement.
   8. Concentrate on your task.
   9. Relax.

Group I was instructed to practice juggling the three balls for *five minutes each day*, while Group II was to practice for *fifteen minutes every second day*. Subjects recorded the greatest number of consecutive catches made in each practice schedule until they had succeeded in making 100

consecutive catches. This was the criterion used to measure when the subject had learned to juggle. It will be noted that the above arrangement provides two different ratios of practice and rest: 1) a short practice followed by 24 hours rest; 2) a longer practice followed by a longer rest. This should permit us to ascertain whether or not the longer practice-rest ratio is as conducive to learning as the shorter ratio.

## Results

Table 1 presents a comparison of the average time required by the subjects in the two groups to learn to juggle. The mean score for Group I was 69.86 minutes and for Group II was 125.80 minutes. The significance of the difference between the two means was computed by using the Student-Fisher $t$ test. A $t$ value of 3.84 was derived which is significant at the 1 per cent level of confidence.

It will be noted that there are 35 subjects reported for Group I and only 31 subjects for Group II. Actually there were 4 more subjects in Group II when the experiment started, however, 4 gave up after they had spent

TABLE 1

*Comparison of the five minute daily and the fifteen minute every second day groups in terms of the mean number of minutes required to learn to make 100 consecutive catches in juggling three balls*

| GROUP | N | MEAN | $\sigma$ | DIFF | $\sigma_{diff.}$ | t | P |
|---|---|---|---|---|---|---|---|
| Five minute daily | 35 | 69.86 | 48.20 | 55.94 | 14.98 | 3.84 | < 01 |
| Fifteen minutes on alternate days | 31 | 125.80 | 68.60 | | | | |

over 200 minutes in trying to learn. Hence, their scores would not make the difference between the performances of the two groups less significant.

Inspection of the individual learning times of the subjects revealed wide differences. The range in Group I was from 19 minutes to 210 minutes while in Group II it was from 40 minutes to 270 minutes. The fastest subject in Group I learned more than eleven times as fast as the slowest subject in that group. Such wide variation in individual performance within these groups would seem to be as noteworthy as the difference between the average group performances.

*Discussion of Results.* The magnitude of the difference between the average performances of the two groups was startling to the authors. Whereas a substantial amount of individual variation might have been predicted, it is doubtful whether anyone would have forecast such a significant difference between the average group scores. The longer practice-rest ratio was certainly not as conducive to efficient learning as the shorter ratio. But, it should be noted that the subjects using the longer ratio learned to juggle in only 8 plus periods while it took the subjects

using the shorter ratio 13 plus periods to reach our criterion. On the basis of these data it seems probable that one can compensate for missed practice sessions by engaging in longer work periods, at least as far as the number of such periods is concerned. Nevertheless, this procedure is relatively inefficient in terms of the amount of actual practice time.

To what shall this difference in learning rate be attributed? If Franklin and Brozek's[8] evidence relating to the ineffectiveness of changing the rest interval is accepted then the length of the work period must be the important factor. However, Travis[9] has equally good evidence which indicates that the length of the rest interval does play an important role in motor learning. Just why the shorter work-rest sessions facilitated more rapid learning remains a moot question. Possible determiners might be found in several of the concepts most frequently used to explain such results. Fatigue may have played a part. Motivation also undoubtedly entered the picture since the subjects' attitudes during the longer work periods were noticed to change. Frequently the men became tense, poorly coordinated, and irritated because of their inability to master the skill. Perhaps, too, the shorter work-rest ratio permitted differential forgetting to operate more effectively.

Attention should be directed to the usefulness of the demonstration experiment technique as a teaching procedure. It may confidently be stated that the men learned much more than just juggling during the course of the experiment. For example, a constructive attitude toward experimentation and research was developed by most of the students. Numerous comments were made to the effect that "maybe there is something to this research business after all." Certainly there was noticeable improvement in the interest and zest with which the students approached the study of teaching methods.

## Summary and Conclusions

The present study has described a demonstration of the effect of two different practice-rest conditions in learning to juggle. College seniors in physical education were selected as subjects. After eliminating those who were able to make five or more consecutive catches on a pre-test, the men were placed in one of two groups by means of random selection. The groups possessed an equivalent amount of athletic experience, as measured by high school letters and college varsity letters. The subjects in Group I practiced juggling 3 paddle tennis balls for five minutes daily until they were able to make 100 consecutive catches, while Group II practiced the same skill for fifteen minutes every second day.

[8] Joseph C. Franklin and Josef Brozek, "The Relation between Distribution of Practice and Learning Efficiency in Psychomotor Performance," *Journal of Experimental Psychology*, XXXVII, No. 1 (February 1947), 16–24.

[9] Roland C. Travis, "Effect of the Length of the Rest Period on Motor Learning," *Journal of Psychology*, III (January 1937), 189–94.

The data from this demonstration indicate that: 1) the five minute daily practice sessions facilitated more rapid learning than the fifteen minute every second day sessions, one minute of practice in Group I proving to be as effective as 1.80 minutes in Group II; 2) fewer practice periods will be needed to learn a motor skill when a longer work-rest distribution is used; and 3) wide individual differences may be expected in the learning of motor skills even among subjects who have had wide experience in related skills.

# Guide to Authors

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Literature citations should be numbered consecutively in the order of their appearance. Their location in the text should be indicated by full-sized figures enclosed in parentheses. For example, (1, 2, 3). Care should be exercised to segregate footnotes from literature citations.

A uniform style should be maintained in writing citations. Quote titles of chapters and articles. Italicize [underscore] names of books and publications.

A uniform sequence of data should be observed. The preferred sequence is: Author's name—title of article or chapter—name of book or publication —volume number—page numbers—year date.

EXAMPLE OF FOOTNOTE

[3] H. Harrison Clarke. *The Application of Measurement to Health and Physical Education.* New York: Prentice-Hall, Inc., 1946. p. 240.

EXAMPLE OF REFERENCES APPEARING AT END OF ARTICLE

1. Ogden, Jean, and Jess Ogden. *Small Communities in Action.* New York City: Harper & Brothers, 1946. (books)
2. Deaver, G. G. Exercise and heart disease. *Research Quarterly,* **10**:24–34, 1939. (periodicals)

or

1. Deaver, G. G., "Exercise and Heart Disease," *Research Quarterly* **10**:24–34 (1939). (periodicals)

## Use of Numbers

Use figures for all definite weights, measurements, percentages, and degrees of temperature (for example: 2 kgm., 1 inch, 20.5 cc., 300°C.). Spell out all indefinite and approximate periods of time and other numerals which are used in a general sense (for example: one hundred years ago, about two-and-one-half hours, seven times). Spell out numbers through nine; arabic figures for 10 and over.

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The metric system being in universal usage, standard abbreviations should be used whenever the weights and measurements are used with figures, i.e., 10 kgm., 6.25 cc., etc. The forms to be used are: cc., kgm., mgm., mm., l., and m. *Gram* should be spelled out in all cases to avoid possible confusion with grain. All obscure and ambiguous abbreviations should be

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*Continued from May Quarterly*

# RESEARCH ABSTRACTS

**Prepared by the Research Abstracts Committee of the Research Section, Carolyn W. Bookwalter, Chairman**

## Anatomy and Physiology

37. SULLIVAN, WALTER EDWARD, OTTO AXEL MORTENSEN, MERYL MILES, AND LAURENTINE STEENSLAND GREEN. Electromyographic studies of M. biceps brachii during normal voluntary movement at the elbow. *Anat. Rec.*, v. 107, no. 3, July, 1950.

Action potentials were recorded from M. biceps brachii of normal subjects during voluntary movements of the elbow joint. A modified electrocardograph and surface electrodes were used. A standard set of movements was performed: 1) elbow flexion (acceleration), forearm supine and prone; 2) elbow extension (negative acceleration), forearm supine and prone; 3) hold (zero acceleration), forearm supine at 135°, 90°, 45° flexion. Film speed was 2.5 cm a second. Loads of zero, 1.0 kg and 2.0 kg were used. Repeated recordings from one subject at the same sittings were usually similar. Repeated recordings from one subject with intervals of weeks intervening usually, but not always, gave similar patterns. Action potentials tended to be higher on the earlier trials than on the later ones. When two or more subjects were studied under similar conditions the recordings were similar or different in pattern and/or amplitude. The variations in pattern and amplitude were assumed to represent differences in the use of the muscle during a given movement. Potentials of lower amplitude were recorded from both parts of the muscle when the movement was performed with the forearm in the prone position and, in general, from the short head under all conditions studied. —*The Wistar Institute.*

38. FINKLER, RITA. Functional sterility and amenorrhea. *Mod. Med.* **18:** 5, 1950.

Dr. Finkler has found irradiation slightly preferable to hormone therapy in cases of pituitary-ovarian hypofunction, i.e., for functional sterility and amenorrhea, X-ray therapy obtained desired results more quickly and slightly more often than hormone therapy. After X-ray therapy on women patients desiring children, 35% conceived after medication. Menstruation was restored in 46% of those receiving X-ray therapy *vs.* 41% under medication.—*A. C. Kelly.*

39. HORVATH, STEVEN M. AND STELLA Y. BOTELHO. Orthostatic hypotension following hot or cold baths. *J. Applied Physiol.*, **1(8):** 586–596, 1949.

Twenty-two subjects, including 9 males and 13 females, after preliminary testing were subjected to hot and cold baths of either 18° or 40° ± 0.2°C and following immersion, returned to the ballistocardiograph where stroke volume and cardiac output were determined in supine and erect positions. Passive alteration of posture from supine to erect (70°) was accompanied by an elevated heart rate and a reduced stroke volume. Cardiac output was increased slightly in those individuals who later developed abnormal responses to change in posture following heat stress, but was lowered in those who were able to tolerate the shift without difficulty. Approximately one-half of subjects developed orthostatic hypotension following immersion in hot bath for 20 min. This result seems to be caused by a combination of pooling of blood and fluid in the extremities, and a failure of the presso-sensible reflexes to increase cardiac output. Erect posture was maintained with greater ease and reduced cardiovascular demands following a cold bath.—*J. M. Boutwell and P. V. Karpovich.*

40. MESHCHAN, I., J. SCRUGGS, JR., AND J. CALHOUN. Spinal fracture from electric shock therapy. *Mod. Med.* **18:** 13, 1950.

In a study of 212 male mental cases receiving electric shock treatment, it was found that 35.4% received injury to vertebral bodies. In the 75 injured patients, the average number of fractures each was 2.56. The 3rd, 4th and 5th dorsal were predominantly affected. Four fifths of the fractures occurred in the first 5 treatments.

Use of curare reduced occurrence of fractures, but as it is a dangerous drug, recommendation was made that its use be confined to cases showing anterior narrowing of bodies. Cases of this type were found to have a higher percentage of fractured bodies (but not the narrowed ones themselves).—*A. C. Kelly.*

41. MILLER, A. T., JR., AND J. O. MILLER, JR. Renal excretion of lactic acid in exercise. *J. Applied Physiol.*, **1(8):** 614–618, 1949.

Blood lactate concentration and total urine lactate during exercise and recovery were determined in 72 experiments on 2 subjects. Apparent renal threshold is approximately 60 mg.%. Lactate clearance is 1 to 2 ml/min. at rest and rises to 15 to 20 ml. min. in exhausting exercise. Urine lactate may be considered only as an approximate index of total lactate production in exercise.—*P. V. Karpovich.*

42. RAMSEY, GLENN V. Sexual growth of Negro and White boys. *Human Biology*, **22:** 146–49, 1950.

The data were secured by the personal interview technique as reported by 37 Negro boys and 286 White boys. The Negro boys ranged in age from 11 to 16 years; the White boys from 10 to 20 years, 85 per cent from 12 to 16.

The results indicate very little racial differences in the three measures of sexual growth. The median age reported for first ejaculation by Negro boys was 13.8 years and for Whites was also 13.8; for the first appearance of pubic hair for the Negro group was 13.3, for the White group, 13.6; and the first recognition of voice change was 13.7 for the Negro males and 13.4 for the White males. These data are in close agreement with those provided by Kinsey et al.—*D. B. Van Dalen.*

43. ROSWIT, B., J. SORRENTINO, AND ROSALYN YALOW. The diagnostic role of radioactive isotopes. *Mod. Med.*, **18:** 6, 1950.

As organized for diagnostic work, a radioisotope unit consists of pathologist, radiologist, biochemist, medical internist, hematologist, and radioisotope physicist. Fundamental research indicates that such units may become an important part of service in hospitals. The authors discuss the diagnostic role of seven of these radioisotopes which already have proved valuable to medicine.—*A. C. Kelly.*

44. SANDOW, A. Muscle. *Ann. Rev. Physiol.*, **11:** 297–334, 1949.

Primary interest is in studies concerned with the fundamental problems of contraction of skeletal muscle. References are cited under the headings of Mechanics, Myothermy, Bioelectricity and Excitability, Ultrastructure, Enzymology, and Mechanism of Contraction, and Miscellaneous.—*G. M. Gloss.*

45. SPIRO, ROBERT K., EVAN R. GOLTRA, AND JOHN S. THOMPSON. Experiments with the Eve method of artificial resuscitation. *J. Applied Physiol.*, **1(4):** 285–297, 1949.

A series of 5 experiments performed to determine the efficiency of the method. Results show the method provides adequate lung ventilation. Rocking tidal air values were greater than normal at rest by 50%. Method does not cause discomfort to patient. Preferred rate of rocking is 12/min. and maximum angle of 30° tip. This rocking procedure raises cardiac output as calculated by Erlanger-Hooker formula (product of pulse pressure and pulse rate).—*J. M. Boutwell and P. V. Karpovich.*

46. WALKER, A., AND T. HOPPLE. Brain tumors in children. *Mod. Med.* **18:** 5, 1950.

Because of the brain's compensatory power, symptoms of cranial tumors in chil-

dren are frequently not noticed until the tumor is large enough to produce "intracranial hypertension by mass blockage of ventricular fluid or both." The general prognosis is not good, but cerebellar astrocytomas and some cerebral tumors may be removed successfully.—*A. C. Kelly.*

## Anthropometry

47. Dupertuis, Clarence Wesley. Anthropometry of extreme somatotypes. *Am. J. Phys. Anthrop.*, n.s. v. 8, no. 3, (September, 1950).

Anthropometric measurements taken on 30 somatotypes showed ectomorphs to be vastly different from endomorphs and mesomorphs. Significant differences of means between the latter two groups occured mainly in trunk diameters and circumferences.

Results indicated that head and face measurements and body and limb lengths failed to differentiate well between the three groups of extreme somatotypes. Lateral and anteroposterior diameters of the trunk, and circumference measurements showed greater differences. They were not so successful, however, as Sheldon's needle point measurements on the photographs for discriminating between morphological types. The conclusion is reached that anthropometric measurements on the living are only moderately successful in demonstrating anatomical differences between extreme somatotypes and are of questionable value in differentiating between the midrange and closely related somatotypes.—*The Wistar Institute.*

48. Garn, Stanley Marion, and Menard M. Gertler. An association between type of work and physique in an industrial group. *Am. J. Phys. Anthrop.*, n.s. v. 8, no. 3, (September, 1950).

A number of recent studies have demonstrated associations between body-build on the one hand and interests, attitudes and choice of professions on the other hand. The present study was concerned with the physical differences between a factory group in Cambridge, Massachusetts, and 20 members of that group engaged primarily in research. In somatotype components the research group was significantly less endomorphic, less mesomorphic and more ectomorphic. The modal research somatotype was ectomorphic as compared to a bimodal endomorphic—mesomorphic distribution for the factory group, the height-weight index, and the majority of the anthropometric measurements confirmed the impression of greater linearity in the research group. Twelve out of 31 measurements and indices showed significant differences in the direction names; these included face measurements and indices as well. It was shown that the greater linearity of the research group could not be attributed to age or education, but within the limits of the study, seemed to represent a predilection of ectomorphic physiques for non-routinized, non-aggressive occupations, such as research.—*The Wistar Institute.*

## Education

49. Bloch, H. A. Alcohol and American recreational life. *Amer. Scholar*, **49**: 54–66, 1948.

The author concludes: despite reform movements and efforts to modify the country's drinking habits, our outlook relative to this entire problem is so entrenched, due to historical necessity and established recreational patterns, that success in transforming our habits is rather dubious . . . mass reformation of drinking habits suggests the need for concerted attack upon the personality-producing tensions in American life and the modification of certain phases of the entire recreational patterns reflected in our culture.—*G. M. Gloss.*

50. Petersen, Jane M. An Illinois group activity test. *Publ. Personnel Rev.*, **10**: 222–225, 1949.

A test for selecting Recreation Aides. Test is a group activity situation in which the candidates participate in games, folk-dancing, and athletics. The technique appears to have face validity and it has been very well received.—*G. M. Gloss.*

51. SCHREK, ROBERT. A graphic method for comparing percentages and means of control and experimental groups. *Human Biology*, **22**: 65–70, 1950.

A special graphic method was developed to facilitate the presentation of a comparison of experimental and control groups with respect to percentages and means. This graph simplifies the presentation of statistical import to readers who are not statistically trained.—*D. B. Van Dalen.*

## Health and Safety

52. KAMM, A. Swimming as an active therapy. *Ment. Hyg. N. Y.*, **33**: 417–423, 1949.

Methods and techniques for training the mental patient how to swim and to obtain therapeutic benefits from this activity. The author shows that "The achievement of results depends partly on facilities and equipment, but primarily on teaching methods and the leadership available . . ."—*G. M. Gloss.*

53. TUTTLE, W. W., MARJORIE WILSON, AND KATE DAUM. Effect of altered breakfast habits on physiologic response. *J. Applied Physiol.*, **1(8)**: 545–559, 1949.

Six women subjects were subjected to controlled breakfast habits and twice a week performed on the bicycle ergometer between 11:00 and 12:00 noon to determine maximum work output. Omission of breakfast caused decrease in maximum work output, increase both in simple and choice reaction time, and increase in tremor magnitude. Coffee alone caused a decrease in maximum work output, and choice reaction time, and an increase in tremor of an outstretched arm. Light breakfast caused a significant improvement of maximum work output and choice reaction time, and a decrease in tremor magnitude. Experiment showed that there are considerable individual differences in response to altered breakfast habits. A direct comparison of the physiologic responses during light and heavy breakfast periods could not be made because the breakfast period of coffee only occurred between heavy and light breakfast.—*J. M. Boutwell and P. V. Karpovich.*

54. WEEK, ERLING FINCH, AND FRANK JEAN SEVIGNE. The utilization of vitamin A alcohol, vitamin A acetate and vitamin A natural esters by humans. *J. Nutrition*, v. 40, no. 4 (April, 1950).

Blood serum vitamin A levels were used as the criterion for determining the relative utilization of the alcohol, acetate and natural ester forms of vitamin A by 18 men and 7 women, after administration of 134,000 $\mu g$ of the vitamin contained in 50 gm of margarine.

For the male subjects, vitamin A alcohol showed greater biological efficacy than vitamin A acetate which, in turn, was superior to the natural ester forms. Vitamin A alcohol produced a greater biological response than vitamin A acetate for the female group; however, comparison of the alcohol form with a distilled natural ester preparation showed no significant difference in utilization. The experimental data were subjected to analyses of variance, and the statistical significance of a great part of the data was established. The addition of 300 mg of tocopherols to the vitamin A alcohol supplements had no appreciable effect on vitamin A absorption.

After ingestion of high dosages of the vitamin, the increased vitamin A in the blood serum was present as the ester, irrespective of the chemical form of the vitamin administered in the supplement.—*The Wistar Institute.*

55. ZIMMERMAN, F., AND BESSIE BURGEMEISTER. The effect of glutamic acid on borderline and high-grade defective intelligence. *N. Y. State J. of Med.*, **50**: 6, 1950.

Eighty-five patients, borderline, and some at upper end of defective range, 4 to 18 years of age, received glutamic acid therapy for one year. Results showed that glutamic acid was effective in raising the intelligence level in 66% of cases. Progress was less pronounced in children with severe behavior problems and in those with gross cerebral pathology.—*A. C. Kelly.*

## Psychology

56. Gagne, R. M., Katherine E. Baker and Harriet Foster. Transfer of discrimination training to a motor task. *J. Exp. Psychol.* **40:** 314–328, 1950.

A control group of 28 men made 60 responses each in a motor learning situation that required S to hit one of 4 switches in response to one of 4 signal lights, the stimulus and response being identified by both position and color. One experimental group of 56 Ss received 30 trials on color discrimination of the signal lights while another 56 Ss practiced on position only. Both experimental groups then did the motor problem involving both color and position. The preliminary training with either discrimination resulted in considerable positive transfer to the motor task. The two types of training were equally effective in speeding up response time, but training in color discrimination, which was the more difficult discrimination, was more effective in reducing error. —*F. Henry.*

57. Kanjilal, P. The emergence of natural muscular rhythm: a preliminary report. *Indian J. Psychol.*, **19:** 78–85, 1944.

A brief report of a rhythmic experiment in which six boys and six girls were asked to press a rubber bulb continuously until told to stop. Definite rhythmic patterns emerged in all cases with marked individual differences in rhythmic types. An appendix presents detailed data.—*G. M. Gloss.*

58. Riopelle, A. J. Psychomotor performance and distribution of practice. *J. Exp. Psychol.* **40:** 390–395, 1950.

The complex reaction time of 20 college students making 40 trials massed in one day was compared with that of 23 students who practiced at 4 trials per day for 10 days. The distributed practice was considerably more effective, the degree of superiority increasing throughout the learning period. For massed practice, initial scores correlated only .03 with gains compared with .31 for distributed practice.—*F. Henry.*

59. Sweigard, Lulu E. (New York U.) Psychomotor function as correlated with body mechanics and posture. *Trans. N. Y. Acad. Sci.*, **11:** 243–248, 1949.

Individuals have a persistent posture pattern which influences movement activities developed mainly from conditioned neuro-muscular action. Mental activity involving thought of movement is the most efficient re-conditioning technique. Eight "lines of action" isolated by the author may be used in reconditioning poor posture. —*G. M. Gloss.*

60. Waters, R. H. and J. G. Reitz. The role of recency in learning. *J. Exp. Psychol.*, **40:** 254–259, 1950.

The validity of 'recency' as a principle of learning has been denied on both theoretical and experimental grounds. In the present experiment, 10 Ss served as a control group in the learning of a raised-wire finger maze, and 10 Ss shifted from right to left hand repeatedly as well as shifting posture from standing to sitting during the last 5 to 15 trials. This did not alter the amount of learning, its variability, or successful prediction of later choices based on 'recency.' Choices made at any particular choice point predicted the next choice at that point with an accuracy of 70%. Since the Ss had a set to learn, were learning and continued to learn in spite of shifts in bodily orientation, it was concluded that successful prediction in terms of 'recency' is a function of 'what the organism is trying to do'—thus 'recency' is not a causal law, but a condition that *allows* learning to operate.—*F. Henry.*

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